VARIATIONS IN THE QUALITY OF COAL IN SON-MAHANADI GONDWANA BASIN

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By

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DEDICATED

TO

MY BELOVED FATHER

WHOSE LOVE AND AFFECTION ABOUNDS NO LIMIT

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It is certified that the research work presented in this dissertation has been carried out under my supervision at the Department of Geology, Aligarh Muslim University, Aligarh. The research work presented here has not been published anywhere in part or in full.

I recommend that Mr. Naushad Ahmad Ansari be allowed to submit the dissertation for the award of the degree of MASTER OF PHILOSOPHY IN GEOLOGY of the Aligarh Muslim University, Aligarh.

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Introduction

PURPOSE OF STUDY

The Son-Mahanadi Gondwana basin belt of peninsular India exhibits significant differences in the stratigraphy, lithologic association and geometry of coal seams, from those of the Koel-Damodar basin belt of eastern India (Pascoe, 1959; Robinson, 1969; Casshyap, 1977, 1981; Mitra et al., 1979). Further, the associated coal seams of the two basin belts also differ in their chemical character and rank, although a great deal of work is yet to be carried out in this regard in both the basins. The purpose of this study is to investigate the physical and chemical characters of coal considering it as one of the facies of the lithic fill.

CHOICE AND LIMITS OF THE AREA

The study here reported is a pilot project to analyse the quality of coal in the Son-Mahanadi basin belt. This basin has been selected for the reason that in spite of its containing huge reserves of workable coal, few studies have been carried out so far to evaluate the fuel properties and rank of coal in the various coalfields of this area (Bose, 1977; Basu, 1981). Recent sedimentological studies have revealed that coal seams of this belt are enclosed mostly in sandstone bodies; they are high in ash, laterally impersistent and have a tendency to split frequently (Casshyap, 1981a; Casshyap and Tiwari, 1983). By contrast, the coal seams of Damodar valley coalfields of eastern India are thick, laterally persistent, and are associated with the sediments which abound in fine clastics (Casshyap, 1981b).

The Son-Mahanadi valley basin is roughly funnel-shaped, narrow towards southeast and broad towards northwest (Fig. 1). The area lies between N. Latitudes 21°30' and 24°30' and E. Longitudes 80°45' and 85°. It includes a number of important coalfields, such as, Talcher, Korba, Mand-Raigarh, Hasdo-Arand, Chrimiri, Sohagpur and Singrauli. This study is concerned with the fuel characteristics of coal from Talcher, Korba, Chirmiri and Sohagpur coalfields.

SCOPE OF STUDY

The study aims at differentiating thechemical characters of coal in vertical sequence and depth of burial. Only workable coal seams have been selected from different coalfields for which the proximate chemical data are available. The coal seams from Talcher, Korba, Chirimiri and Sohagpur coalfields were subjected to investigation. The basic data comprising proximate constituents of coal for various seams are obtained from the relevant publication of the Central Fuel Research Institute, Dhanbad (vols. 5 and 6, 1979). The results of analyses have been computed statistically for ash, volatile matter and fixed carbon, and plotted graphically with the help of triangular plots, variation lines and histograms.

PREVIOUS WORK

A great deal of work has been done on the petrology of Indian coals during the past three decades (Raistrick and Marshall, 1939; Ganju, 1955a, 1955b, 1960; Ganju and Pant, 1963; Pareek, 1963; Pant, 1965; Navale, 1965; Stach et al., 1982).

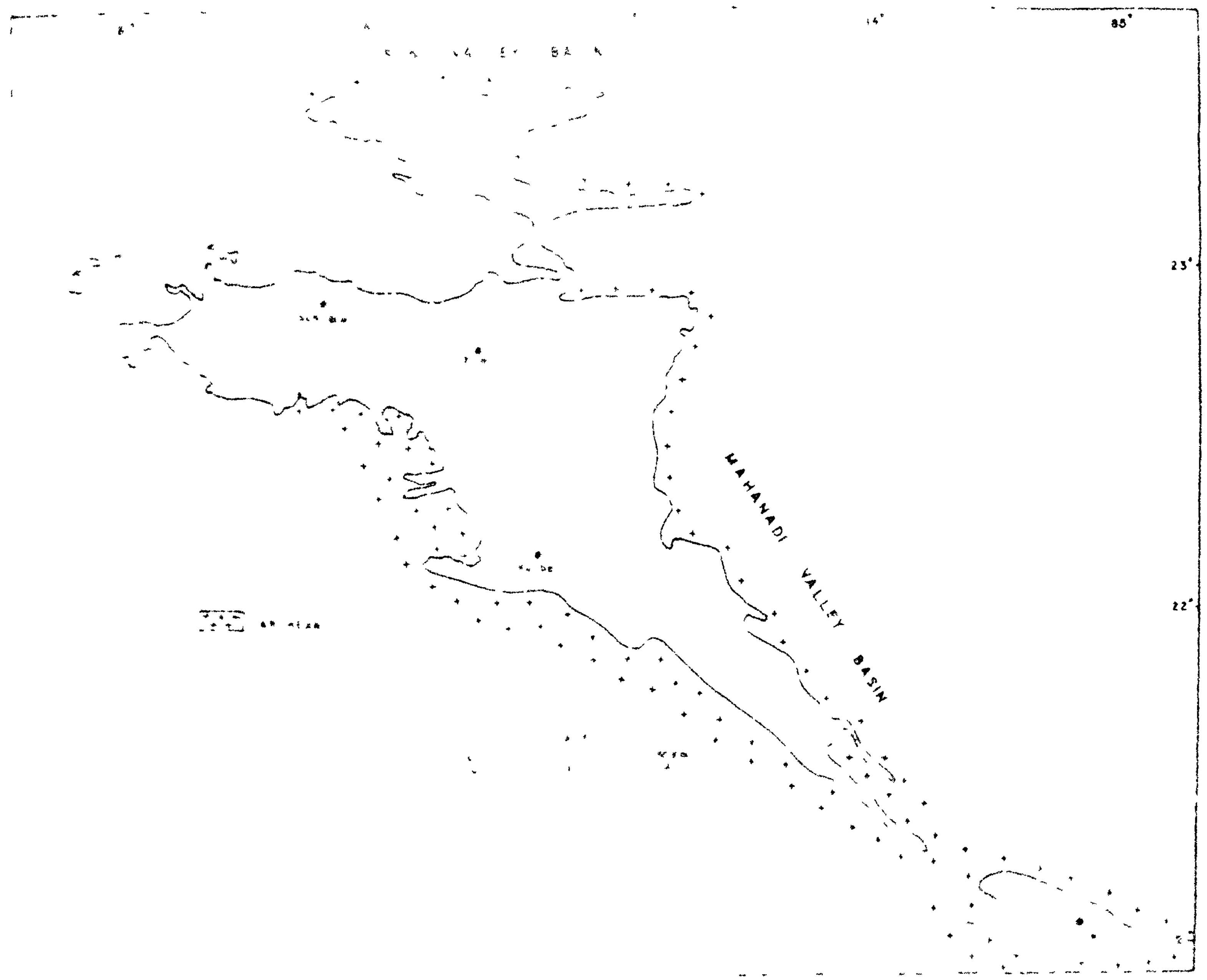


Fig. 1 : Location Map of the Area

Likewise, the associated coal bearing sediments have been investigated for their stratigraphy and sedimentology(Ahmad,1960; Robinson,1969; Ghosh and Mitra, 1972; Casshyap, 1973,1977,1981 ; Mitra, et al., 1979; Laskar, 1979) more in Damodar Valley basin than the Son-Mahanadi Gondwana belt. However, no serious attempt has so far been made to study systematic variation in quality of coals of Son-Mahanadi Gondwana basin. The available literature on chemical properties of coals of this basin includes the results of proximate and ultimate analyses of Gondwana coals (CFRI,1979; Bose, 1977; Basu, 1981). Some studies have also been made with reference to paleogeothermal gradient, depth of burial and coalification(Chaudhary,1979; Basu and Shrivastava, 1981).

Chapter-I

STRATIGRAPHIC SETTING

The workable coal seams of Son-Mahanadi basin belong to late paleozoic (Permian) Karharbari and Barakar formations of the Lower Gondwana sequence. Table 1, records the stratigraphic subdivisions of the Lower Gondwana sequence, as recognised in this basin belt (Mitra et al., 1979). The geological maps as reproduced here show the distribution of Lower Gondwana formations in the various coalfields of Son-Mahanadi basin, including Talcher (Fig.2), Korba (Fig.3), Chirimiri (Fig.4) and Sohagpur (Fig.5).

Talcher Formation

The Talcher Formation forms the basal lithostratigraphic units of the Lower Gondwana sequence. It randomly exceeds a few hundred meters in thickness on outcrop sections, but thicker sequences have been recorded in the subsurfaces as in the Korba and Sohagpur coalfields. The Talcher outcrop commonly along the margin of the coalfields or in exhumed valleys in the interior parts of the coalfield as in Tan and Hasdo river sections, north of Korba. It rests upon the Archean basement with an unconformity or with a faulted contact. The Talcher show a wide spectrum of lithofacies includint tillite, diamictite, conglomerate, sandstone and shale, which are conspicuous by the olive green colour on the outcrops.

The tillite facies is more or less massive, locally and partially stratified commonly.

TABLE 1

Lower Gondwana Subdivisions and dominant lithological types (After Mitra et al., 1979)

Period	Subdivisions		Lithology
Upper Permian	Panchet Formation Raniganj Formation	KAMTHIS	Brown and yellowish brown sandstones and clay
Middle Permian	Barren Measures		Thick as well as thin sandstone. Grey, dark thick shale and clay containing sideritic nodules.
Lower Permian	Barakar		Greyish to buff colour, fine to very coarse gritty and pebbly sandstone alternating with carbonaceous shale, coaly shale and seams, with basic conglomeratic layer.
	Karharbari		Pebbly sandstone, conglomerate, askose, carbonaceous sandstone, shale, carbonaceous shale and coal seams.
	Talchar		Predominantly olive-green laminated shale, interbedded green sandstone, silt stone and shale containing dropstones, olive green sandstone with conglomeratic bands, Diamictite (Poorly sorted).

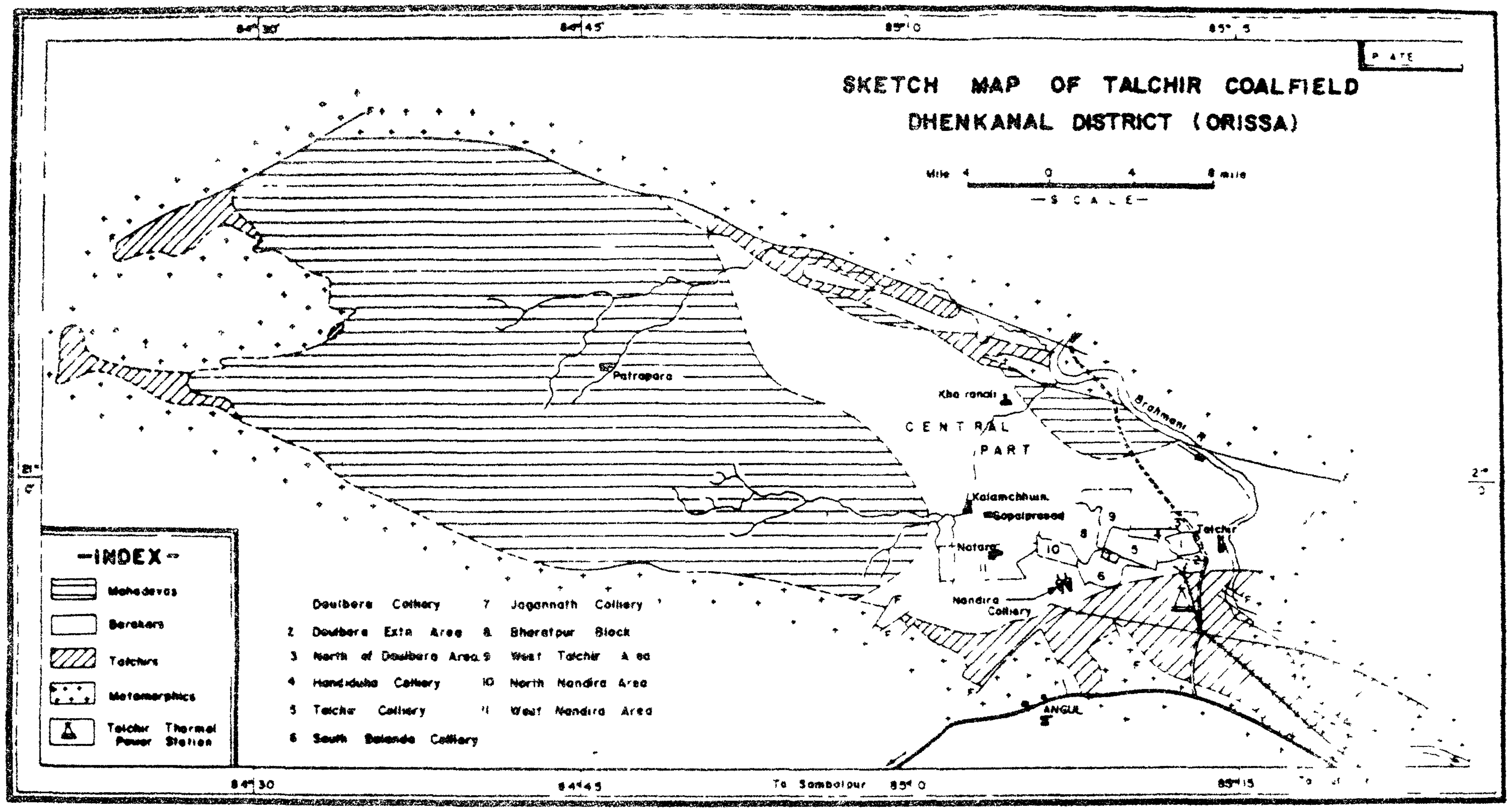


Fig. 2 : Geological Map of Talcher coalfield showing blocks/areas from where analyses were considered.

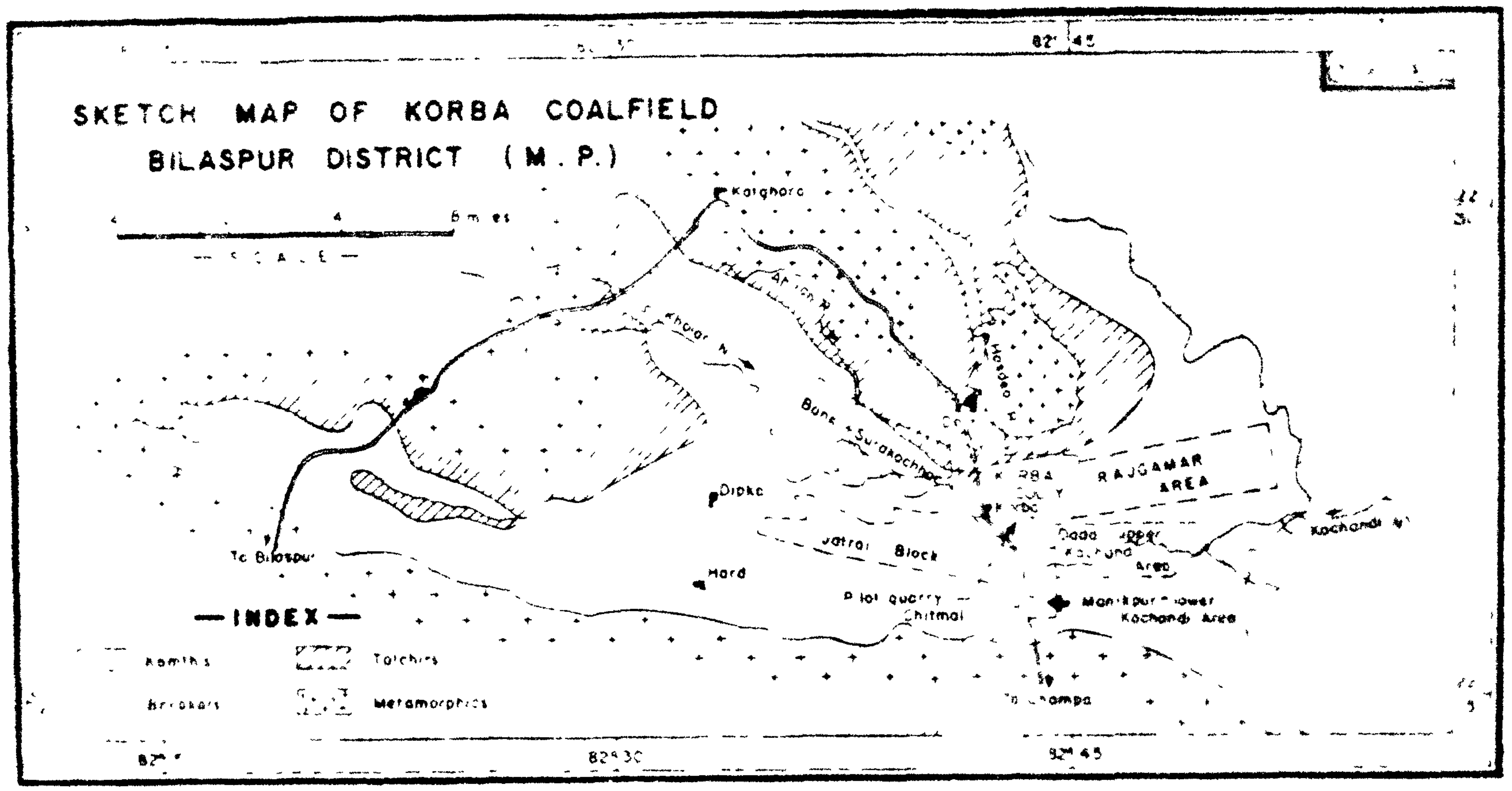


Fig. 3 : Geological Map of Korba coalfield.

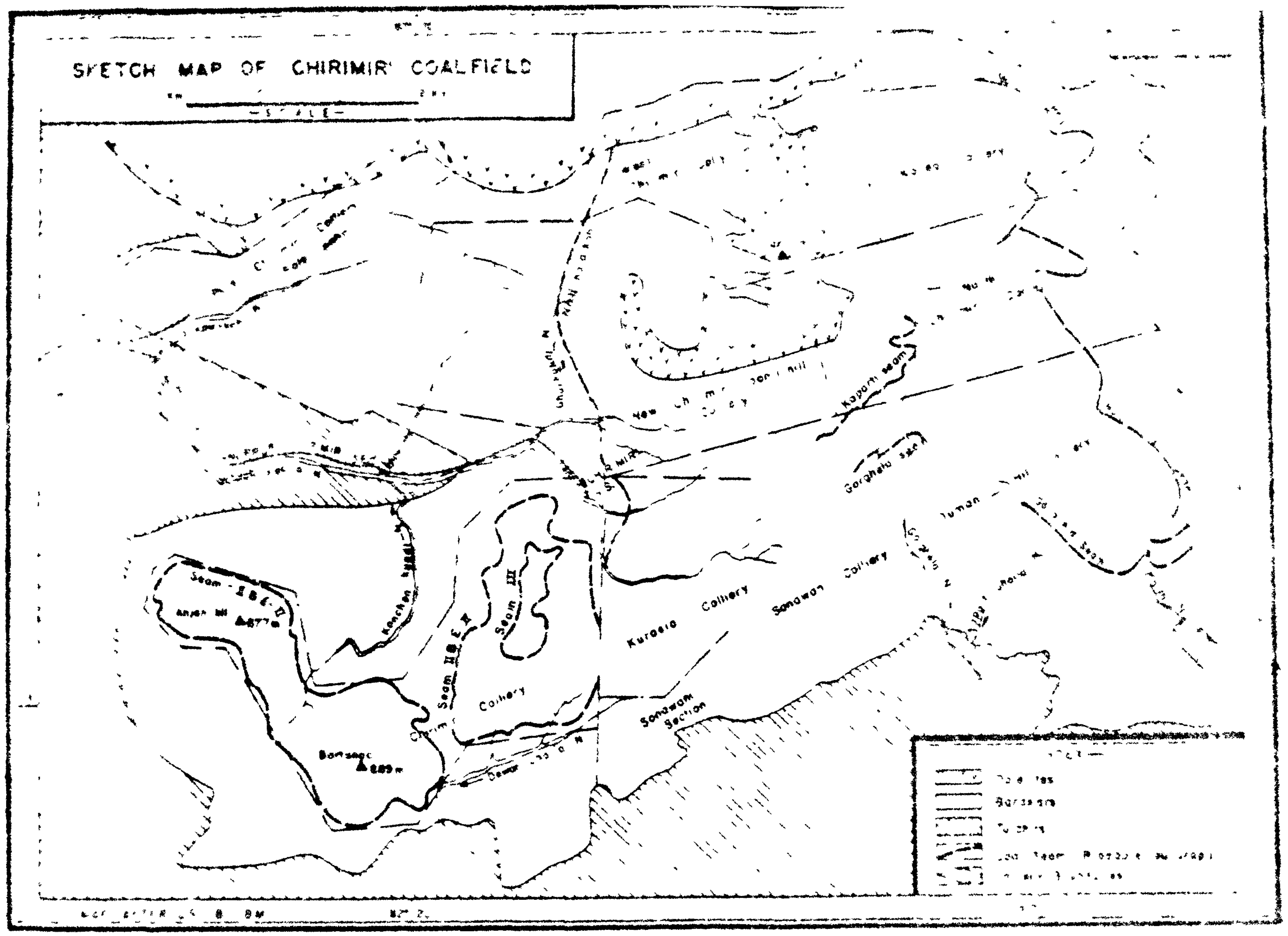


Fig. 4 : Geological Map of Chirimiri coalfield.

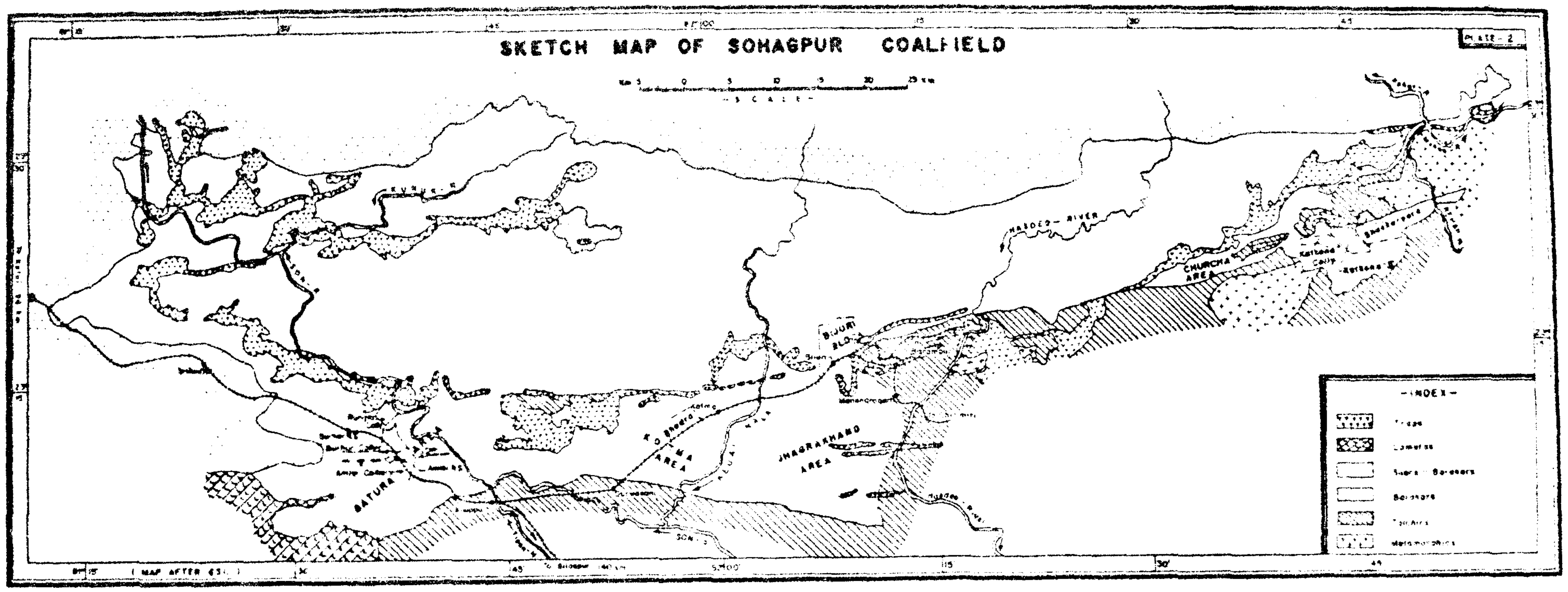


Fig. 5 : Geological Map of Sohagpur coalfield.

Sandstone is coarse to medium grained and shows parting lineation, small and large scale cross-stratification and occasionally ripple marks. The shale facies constitutes major lithofacies of the Talcher Formation. It includes needle shales, black shales, and silty shales. The needle shales are highly characteristic and make up a considerable portion of lithic fill. Fossiliferous marine sandstone and clay facies occur at least at two places in the Son valley, one at the Umaria and the other at Manindragarh separated by a distance of about 175 m. This facies contains marine invertebrate fossils(Shastri and Shah, 1964) of Sakmarian (? Artinskian) age (Frakes et al.,1975).

The Talcher strata have been assigned to glacial and glacio-fluvial origin on the basis of grooves and striations found on the underlying bed rock or sandstone bed, presence of striated pebble clasts, pebble fabric and occurrence of drop stone facies in the sequence (Casshyap and Tewari, 1974).

Karharbari Formation

The Karharbari Formation(Lower Permian) which succeeds the Permo-carboniferous Talcher Formation is thinly developed (70-305 m) and is as a rule dominantly arenaceous in composition(sandstone ~80%) (Casshyap and Tewari, 198). The Karharbari comprises pebbly coarse to medium grained sandstone with occasional bands of conglomerate and thin to thick lenticular shale and coal. The existence of the Karharbari Formation in various coalfields of Son-Mahanadi, which was a matter of controversy, has now been established (Ghosh et al.,1964).

The notable feature of this formation is its remarkable development in the basinal part(corresponding to early phase of fluviatile sedimentation) following the Talchir glaciation. The formation is thickest (207 m) in the northwestern margin (Sohagpur coalfield),(Chaudhary,1979) while it is considerably attenuated in the southeastern margin of the basin(about 6 m). The interbedded sandstone bodies are considered to be formed by channel filling, and such bodies occur predominately(De,1979). The coal seams enclosed in this formation are rich in vitrain (Navale, 1977) and are smaller in thickness than those found in the overlying Barakar Formation.

Barakar Formation

The succeeding Barakar Formation is characterized by the development of a conglomeratic horizon at its base and gradational relation with the underlying Karharbari Formation. Its thickness is about 675 m in Singrauli and more than 800 m in Korba and Talcher coalfields. This formation is also dominantly arenaceous(sandstone 70-84%) like Karharbari, and abounds in coarse to medium sandstone, dark grey shale and thick to thin discontinuous coal seam. The coal seams are invariably embedded in and separated by thin units of sandstone. The lithofacies comprising Barakar exhibit wide spectrum of sedimentary structures of which large and small scale cross stratification are profusely developed.

The Barakar passes upward with gradational contact up to a group of rocks characterized by brown and yellow sandstone and clay, and designated as Supra-Barakar in Talcher coalfield and Kamthi Formation in Korba (Mitra et al., 1979). This group of rocks is termed as the Pali Formation in Western Son valley basin and has been differentiated into Barren Measures and Raniganj Formation in the Singrauli coalfield in the north.

PRODUCTIVE COAL SEAMS

The productive coal seams of different coalfields of Son-Mahanadi basin may be summarized hereunder.

Talcher Coalfield

The productive coal seams of Talcher coalfield occur stratigraphically both in Karharbari and Barakar formation; their sequence as established by the Geological Survey of India (Rao, C.S.R., 1983) is given below:

Strata		Seam	Thickness (m)
Barakar		IV	10 (approx.)
		III	14 to 19
		II	35 to 50
Karharbari I(Main Seam)		Top Section Parting	1.2 to 12
		Middle Section Parting	1 to 12
		Bottom Section	3 to 12

These coal seams are being worked by C.C.L. in various mining areas as demarcated in the geological map in Fig. 2.

Seam I (Main Seam)

It is a prominent coal seam within the Karharbari Formation and is presently being worked in the Deulbera, West Talcher, Balanda and Nandira collieries. It usually occurs about 90 m to 170 m above the Talcher-Karharbari contact and 40 m to 75 m below th Barakar pebble horizon. This seam splits into two or three section.

In Deulbera colliery it occurs in three section, of which the bottom section varying in thickness from 2.08 m to 3.42 m is under exploitation extensively (Tripathi et al., 1977).

In the Balanda colliery area, Seam I occurs as a composite coal horizon (0.61 m to 9.74 m) in south Balanda quarry but splits into three sections both towards dip side to the north and along strike side in the west . The overall thickness also increases upto 18.16 m (inclusive of dirt bands) on dip side .

Seam II

This seam is the lowest seam in the Barakar Formation of this coalfield and occurs 10 m to 15 m above the boulder conglomerate horizon. This seam displays excellent development in the Jagannath colliery where it attains a maximum thickness of over 50 m. An abrupt degeneration of the seam has been observed westward in the vicinity of Natara, where an 18-meter thick grey sandy shale horizon with carbonaceous and coal streaks have been encountered near the surface and 23 m above the pebble bed.

Seams III & IV

Seams III & IV are not considered economic since they are highly interbanded and show inferior quality. Seam III displays an average thickness of about 15 m in Gopal Prasad area whereas Seam IV varies in thickness from1.1 m at the outcrop to 11.5 m down dip in subsurface . The dirt bands in the seam constitute about 20% of the total seam thickness, thereby rendering it unproductive.

Korba Coalfield

The productive coal seams of Korba coalfield are restricted to the lower and upper member of the Barakar Formation and are separated by a barren zone. The lower member is conspicuous by the presence of thin seams of superior quality, while the upper member is rich in thick coal horizons of inferior quality.

The generalized sequence of coal seams in the Korba coalfield is as follows (Joshi et al., 1978) :

Strata	Seam	Thickness (m)
Upper Barakar Member	Upper Kusmunda (upper Jatraj)	13 to 29
	Partin	45 to 88
	Lower Kusmunda (Jatraj)	43 to 67
	Parting with minor seam	80 to 85
Middle Barakar Member	Sandstone	300 (approx.)
Lower Barakar Member	G-III	1 to 4
	Parting	39 (approx.)
	G-II	1.2
	Parting	15 to 20(approx.)
	G-I	1 to 4
	Parting	30 to 40

The Korba coalfield has various coal-bearing blocks/areas, namely : Rajgamar, Londra-Kerla, Korba colliery including Manikpur block, Banki-Surakachar colliery area, Sulmati-Suklahar area etc., as shown in geological map in Fig. 3.

Rajgamar Block

The Rajgamar block is situated some 1[illegible] km. from Korba colliery in the eastern part of the field. Only lower Barakar coal measures are exposed in this block, the sequence of which is as follows (Sen and Rao, 1973) :

Seam	Thickness (m)
R-II	0.9 to 7.14
Parting	55 to 71
R-III	0.17 to 1.85
Parting	27 to 42
R-II	0.6 to 3.10
Parting	19 to 27
R-I	0.3 to 1.5

Of these, Seam R-II is the most important seam of the block. This seam is correlated with G-III seam in Korba and Banki-Surakachar collieries. It is clean except few occurrence of shaly coal bands at places. Seam R-I & R-III both are considered uneconomic because of development of many bands of carbonaceous shale within the seams. Seam R-IV is the thickest seam in the area and ranges from 0.9 m to 7.14 m in thickness.

Korba Colliery Area

The Korba colliery area lie on the easter side of the Hasdo-River and is being worked through the Ramsagar inclines. The coal seams namely G-II, G-III & G-IV are found in this area. Seam G-II & G.IV are too thin and impersistent to be of significance. Seam G-III is under exploitation. The coal is generally clean but a minor shaly coal band ranging in thickness from 0.05 m to 0.17 m occurs.

In the virgin area SSW of Ramsagar inclines, Seam G-III maintains a workable thickness of 1.65 m to 1.96 m.

Banki- Surakachar Colliery Area

The belt of lower Barakar coal measures stretches over a continuous length of 25 km from the west bank of the Hasdo River to Bhejrinara village and even beyond the Bilaspur-Katghora road to the northwest. In this belt, the continuity of the seams namely G-I, G-II, G-III, G-IV and G-V with a cumulative thickness of 12 m has been proved. Of these, G-I and G-III seams are well developed and attain workable thickness over the major part of the area.

<u>Seam G-I</u> : This seam is best developed in the area west of the Hasdo River in Bhairontal- Surakachar area. Here it is usually 2 m to 4 m thick and is characterized by the development of shale bands at the base. The seam gradually thins out westward and attenuates to a thin band of coal beyond the Ba ri Jhari nala.

The seam also shows attenuation towards west. In down dip direction the seam has a tendency to thicken and it attains a thickness of 2 m to 4 m in the area from Purena to Khamaria.

Seam G-III: This seam, also known as Ghordewa Barakar coal measures, is found to be consistent in thickness from 1.5 m to 3.0 m except in small area between Banki-Surakachar, where it is less than a meter thick. Its maximum thickness in the vicinity of Danganice village is 4 m to 5 m. The seam usually shows a tendency to thin slightly towards dip.

Seam G-IV: This occurs as a small band, usually less than a meter in thickness between Bhairontal village and the Hasdo River. This seam serves only as a marker horizon.

Seam G-V: This seam has been found to develop Bajinara and Suklahar villages with a thickness usually less than a meter. The seam is not developed elsewhere in the Korba coalfield.

Manikpur Block :

In Manikpur colliery area, coal horizons of economic value are found in the upper Barakar member. The coal seams of this area exhibit wide variability due to frequent splitting and development of dirt bands. Many coal seams are developed in the area of which seams XVIII(Jatraj) and IX (Upper Jatraj) merit consideration as they have attained economic thickness over large areas.

<u>Seam XVIII (Jatraj or Lower Kusmunda):</u> This seam is under exploitation. It attains its maximum development in the western part of Manikpur block where it is 36 m in thickness. The seam splits into 5 major sections in the Dadar-Pondibahar area. The thickness of the seam including bands varies from 18.4 m to 34.5 m.

<u>Seam XIX (Upper Jatraj or Upper Kusmunda):</u> This seam is highly interbanded in nature and shows a general thickness towards west. It splits into two sections. The lower section is comparatively cleaner as it has less dirt bands. It varies in thickness from 4.6 m to 9.8 m. The upper section is dirtier as dirt bands constitute about 70% of this section.

Chirimiri Coalfield

The productive coal seams in the Chirimiri coalfield with their local name are listed below (IBM, 1962).

Seam	Thickness(m)
III (Duman)	0.2 to 2.2
II B (Top (Parting)	6.0 to 50.0
II B (Kaperti)	0.2 to 8
II B Bottom(Parting)	13.0 to 47
II (Karakoh,Ghorghella, Bijora and No.3 etc.)	1.[illegible] to 19.8
II A (Parting)	15.0 to 60.0
I (Kotmi/Sonawani)	0.1 to 2.3

Eight collieries developed in this coalfield are :

Duman Hill, North Chirimiri, Korea, West Chirimiri, New Chirimiri (Ponri Hill), Chirimiri, Kurasia, and Sonawani colliery (Fig.4).

TISCO Block II (Duman Hill Colliery)

The four coal seams viz. Sonawani/Kotmi, Karakoh, Ghorghella, Kaperti and Duman occur in this colliery.

Sonawani/Kotmi Seam: In the western sector of TISCO block II, the lowermost workable seam is referred to as 'Sonawani Seam' while in the eastern sector the same is designated as 'Kotmi Seam'. The seam has a maximum thickness of 7.8 m on the west and thins down to some extent eastward. There is a thick sandstone parting which splits the seam into two distinct sections. The upper section of the seam with many dirt bands is considered not workable, while the lower section, which has a thickness of 1.5 m to 3.6 m is under exploitation.

Karakoh/Ghorghella Seam: This coal seam is known as Karakoh in western part and Ghorghella in eastern part of the colliery. The Karakoh seam is represented by two coal sections with one moderately thick parting in between. The upper section is 2.1 m to 4.9 m thick while the bottom section is much thinner being 1.1 to 1.8 m thick. The Ghorghella seam affords a clean section of coal without any parting. The seam is thickest in the southeastern part and thins down in other areas.

Kuperti Seam: Kuperti seam is thick horizon in eastern part of this colliery and is characterised by its stone partings which have rendered the major portion of the horizon unworkable. However, in the area east of the Kuperti-Jharia nala, workable portion of coal ranges in thickness between 3 m to 4 m and even more at places .

Duman Seam: The development of this seam is restricted to central part of the colliery. It exhibits a thickness of 1.[illegible] m to 1.[illegible]6 m.

North Chirimiri Colliery

In the North Chirimiri area, there are three coal horizons equivalent to the Kotmi, Ghorghella and Kuperti seams. Kotmi seam has attained workable thickness only in the western part of this colliery. The Ghorghella seam is extensively worked and is under depillaring stage. The seam varies in thickness from 0.35 to 5.65 in north of this area. Kuperti seam is top most seam found in this area. This has a workable thickness of 1.2 m to 5.6 m . The thickness reduces towards west while in the middle portion it is more than 3.5 m .

Korea Colliery(NCDC Block- I & II)

In the Korea colliery, four coal horizons occur, namely Sonawani/Kotmi, Bijora, Karakoh and Duman, of which seam II o.

the Bijora seam is workable and can be correlated with the Karakoh horizon of Kurasia colliery and Ghorghella of Duman hill colliery. The other seams are too thin to merit any description.

The Bijora seam splits usually into two sections Bijora top (II top) and Bijora bottom(II bottom) with a parting of 0.5 m to 4.2 m . The Bijora seam is thickest in the western part, where it is 5.6 m thick including the bands.This seam has a tendency to thin down towards NW and NE.

West Chirimiri Colliery

There are only three coal seams which crop out in this colliery. They are named as Main,Middle and Top seams.

The main seam is equivalent of the Karakoh seam. The general thickness of the seam is 3.5 m to 4.0 m . It is free from dirt bands. The Middle Seam lies over the Main Seam after a sandstone parting of 25.0m thickness. It is equivalent to the Kaperti seam and is about 1.20 m thick. The Top seam lies over the Middle seam and is separated by a 50.0 m thick parting. It is correlated with the Duman seam. The thickness of the seam is about 1.50 m.

New Chirimiri (Ponri Hill) Colliery

Six coal seams namely Seams V,IV,III,II,I and O occur in an ascending order in this colliery.

The seam-V is regionally correlated with the Kotmi seam, whereas Seam-IV is of local occurrence. Both the Seam V & IV are virgin seams. The Seam-III is the most important seam and regionally correlated with Karakoh seam. The bottom working section is generally devoid of any dirt band. This seam, at places, occurs in sections separated by a thick shale band. The Seam-II is regionally correlated with Rapeti seam while Seam-I with Duman seam. The Seam-I is virgin in this area while seam-0 is inferior in quality.

Chirimiri Colliery

Five coal seams excluding the split sections of the Karakoh horizon crop out in this colliery. The Seam-V is tentatively correlated with the Kotmi seam. A 1.5 m section of this seam is worked in Sonawani Colliery. Seam-IV is developed in Chiruma Hills. Seam-III is extensively developed in this colliery. It splits into two sections each having a thickness of about 3 m . This seam is worked in the Bartunga hill and Chirimiri Hill. It is virgin in Anjan Hill. Seam-II has an average thickness of 1.29 m . Seam-I forms a circular outcrop in the Chirimiri hill. It has an average thickness of 2. m . This seam is tentatively correlated with the Raperti Seam.

Kurasia and Sonawani Collieries

The Kurasia and Sonawani collieries are located in the south-central part of the coalfield.

The general sequence of coal seams here is as follows :

Seam	Thickness (m)
Karakoh top section	0.9 to 2.4
Parting	0.35 to 1.6
Karakoh Middle section	1.00 to 4.0
Parting	1.5 to 19.5
Karakoh Bottom Section	1.5 to 7.8
Parting	0.8 to 20.0
Lower Karakoh	0.15 to 3.3
Parting	22.0 to 40.0
Sonawani	0.45 to 2.5
Parting	110

Sonawani Seam:

The Sonawani Seam is the lower most workable seam in this area. It is compact horizon of 1.5 m to [illegible] m thickness in the northern part but thickens too the south due to the development of shale and sandstone partings. The **Lower Karakoh Seam**, like the Sonawani seam, is a clean compact seam in the northern part of Kurasia colliery but towards south it develops shale partings and splits into three distinct sections. The Karakoh seam, the most important seam horizon of the coalfield, splits into three sections - Karakoh bottom, Karakoh middle and Karakoh top with a total thickness of about [illegible] m.

Sohagpur Coalfield

In the Sohagpur coalfield, productive coal seams are confined to widely separated sub-basinal structures like Jhagrakhand-Bijuri, Kurtkonda-Bhaskarpara, and Kotma sub-basins, and others as delineated in the map in Fig. [illegible].

There exists four coal horizons in Jhagrakhand-Bijuri area. The seams in Jhagrakhand sector are numbered as Seam-A, Seam-B, Seam-C, and Seam-D in an ascending order. The same coal seams also occur in the Bijuri sector but here they have been numbered as Seam-D, Seam-C, Seam-B and Seam-A in an ascending order. Thus, Seam-A of Jhagrakhand is the same as Seam-D of Bijuri and so on.

Only Seam-A and Seam-B in Jhagrakhand sector are of economic importance. Seam-A crops out in western part of Jhagrakhand, where it splits into two sections: bottom and top-the bottom section varies in thickness from 1.05 m to 2.8 m and top section has thickness varying from 0.6 m to 1.2 m. On the dip side the split sections have a tendency to coalesce into a single seam which has thickness varying from 1.4 m to [illegible].9 m. This seam in north Jhagrakhand area is devoid of partings and varies in thickness from 1.4 m to 3.1 m. Seam-B is next in importance to bottom section of Seam-A. It ranges in thickness from 1.17 to 2.05 m and is fairly persistent in its thickness in the northern part of the block.

In Bijuri Sector, some 12 km east of Jhagrakhand, the coal seams have been referred to as Seam-D, Seam-C, Seam-B, and Seam-A from bottom to top. Seam-D occurs 100 m to 114 m above the base of the Barakar Formation and has attained workable thickness in the middle part of the block. Seam-C extends over a major part of the block. Its workability is limited to narrow strip in the northwestern part, where it attains a thickness of 2.13 m to 2.92 m. Seam-B is more or less consistent in thickness in the central, southern and southwestern parts of the block. Seam-A, the topmost seam, is considered to be the most important coal seam in this block, because of its fairly consistent thickness, over an area of 3.7 sq.km. The seam has a number of sandy shale and sandstone partings. The thickness of the parting varies from 0.[illegible]5 m to 3.07 m while the thickness of workable coal in the upper portion of the seam varies from 1.2[illegible] m to 2.30 m.

In the Kutkona-Bhaskarpara area of the coalfield, five regular coal seams exist. They are numbered as Seam-I, Seam-II, Seam-III, Seam-IV, and Seam-V in an ascending order but they are more popular by their local names, viz. Kutkona, Ahona, Chhamat, Tengni and Khajura respectively. Of these, Seam-I and III are most important in view of their consistent thickness and quality. The Seam-I, however, thins down to unworkable thickness in Bhaskarapara Sector. At present, Seams I & III are being worked in Kutkona colliery. Seams-II & IV are not considered economic. The Seam-V maintains workable thickness through out the sector. It has thickness varying from 4 to 6 m and is highly interbanded with sandstone, shale and continuous shale.

Chapter II

PROXIMATE CONSTITUENTS OF PRODUCTIVE COAL SEAMS

The proximate constituents are one of the chemical parameters to evaluate the quality and rank of coal (Marshall, 1974; and Stach et al., 1982). They are expressed as percentage of fixed carbon, volatile matter, ash and moisture and have been used in this study to evaluate the variation in the chemical character of Lower Gondwana coal through time (with depth) and space.

Basic Data

The basic data include the results of proximate analyses of selected coal seams of Son-Mahanadi basin, contained in the publication of the Central Fuel Research Institute (CFRI), Dhanbad, Vols. 5 and 6 (1979). The coal seams as here examined belong to Talcher and Korba coalfields of Mahanadi, and Chirimiri and Sohagpur coalfields of Son basin. In each coalfield, four to six workable coal seams from bottom to top representing the (?) Karharbari and Barakar Formations, as listed in chapter I (pp.9-22), have been investigated for this study. Their respective position in the subsurface stratigraphic column in different coalfields based on available bore hole logs is shown in columnar diagrams (Fig. 6). Table 2, below, gives coalfield-wise break-up of coal seams examined and number of chemical analyses taken into account for this study.

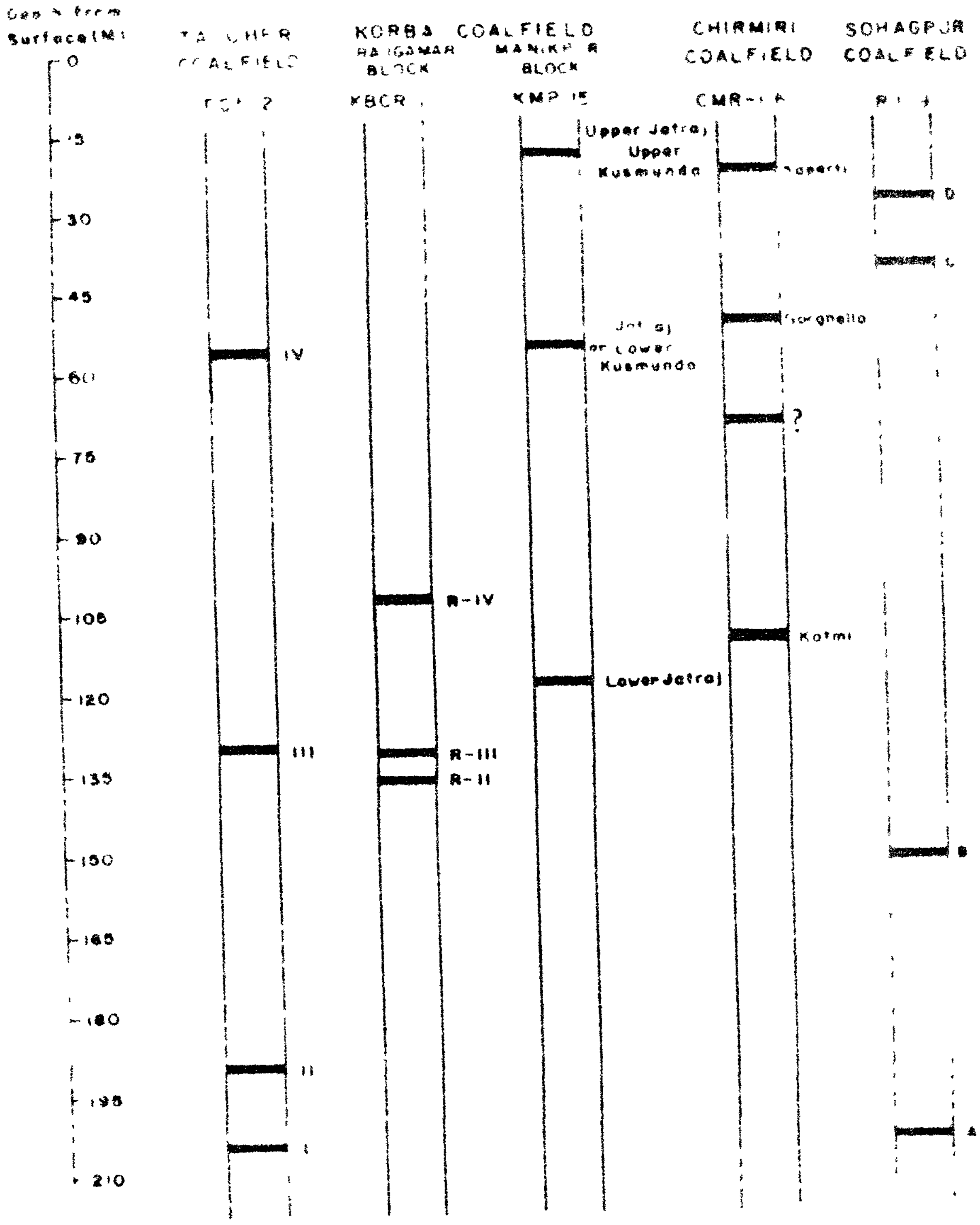


Fig. 6 : Columnar diagrams of coal seams for Talcher, Korba, Chirimiri and Sohagpur coalfields with depth wherever possible.

TABLE 2: List of coal seams and number of chemical analyses used from different coalfields of Son-Mahanadi basin.

Name of coalfield	Coal seams examined	Number of Chemical analyse used.
Talcher (South Mahanadi basin)	IV	4
	III	9
	II(Jagannath)	8
	I(Main Seam)	12
Korba (North Mahanadi basin)	Upper Kusmunda or upper Jutraj.	10
	Lower Kusmunda or Jatraj	10
	Lower Jutraj	4
	Ghordewa-III	6
	Ghordewa- II	4
	Ghordewa- I	7
Chirimiri (South Son basin)	III (Duman)	4
	II B Top	10
	II B	7
	II B Bottom	7
	II (Karakoh, Gharghella, Bijora and No.3)	4(average of 49 analyses from four local seams)
	II A(No.3A)	10
	I(Kotmi/Sonawani)	12
Sohagpur (Jhagrakhand-Bijuri area, west-central Son basin)	D (A)	5
	C (B)	3
	B (C)	3
	A (Jhagrakhand)	5
Sohagpur (Kutkona-Bhaskarpara area, east-central Son basin)	V (Khajora)	6
	IV (Tengni)	6
	III(Chamat)	7
	II(Khand top)	5
	I (Kutkona)	5

The proximate data for the three components (fixed carbon, volatile matter and ash) for all the chemical analyses referred to above were recalculated to 100 per cent, deleting the moisture content which was not considered for this study and are listed separately for each coalfield in Appendix 1-4.

Seam-wis Variation in Proximate Constituents

The proximate data have been analysed to work out the vertical and spatial variation in proximate components within and between different coal seams of each coalfield in order to determine the overall quality and rank of coal.

Talcher Coalfield

Appendix 1 records the recalculated per cent values of fixed carbon, volatile matter and ash for the four coal seams of Talcher coalfield, and also lists their locality, local nomenclature of the seam, wherever possible, and the source of basic data.

The percentage of proximate constituents is plotted on a ternary diagram using separate symbols for each seam (Fig. 7) to show their individual chemical character and variation between them. A definite variation in chemical character of the four coal seams from bottom to top is evident within a thickness of about 800 m of strata and is clearly brought out pictorially with the help of variation lines drawn to show inter-relationship between fixed carbon and volatile matter, fixed carbon and ash, and volatile matter and ash (Fig. 8a). The variation lines show a marked decrease in fixed carbon content from 48.9% to 35.5% as ash

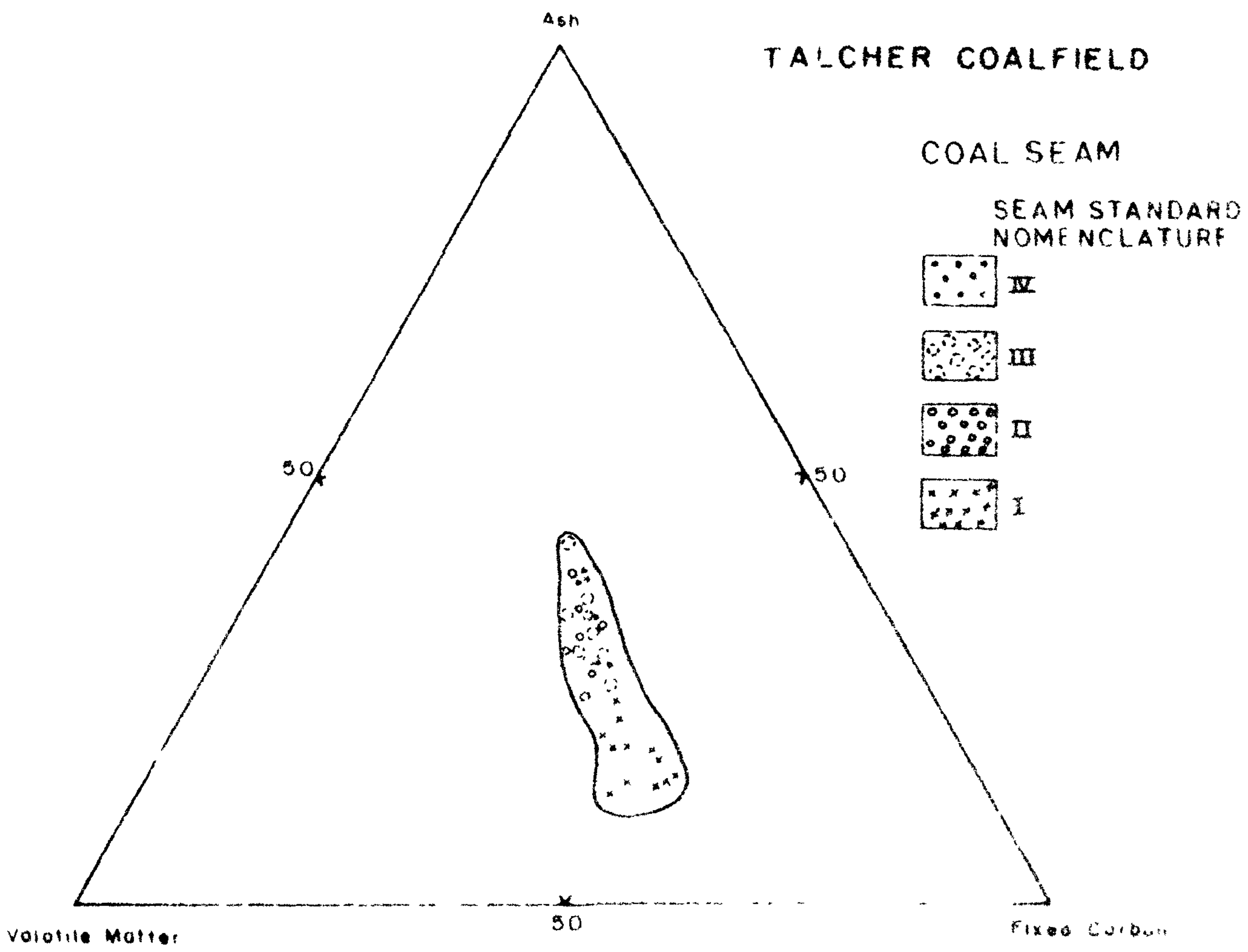


Fig. 7 : A triangular plot showing recalculated percent values of the three proximate constituents in four coal seams of Talcher coalfield.

Fig. 8 : (A) Variation lines showing inter-relationship between the three proximate constituents of coal seams with depth in Talcher coalfield,

(B) Triangular plots for each of the four seams of Talcher coalfield showing temporal variation in proximate constituents from bottom to top seam.

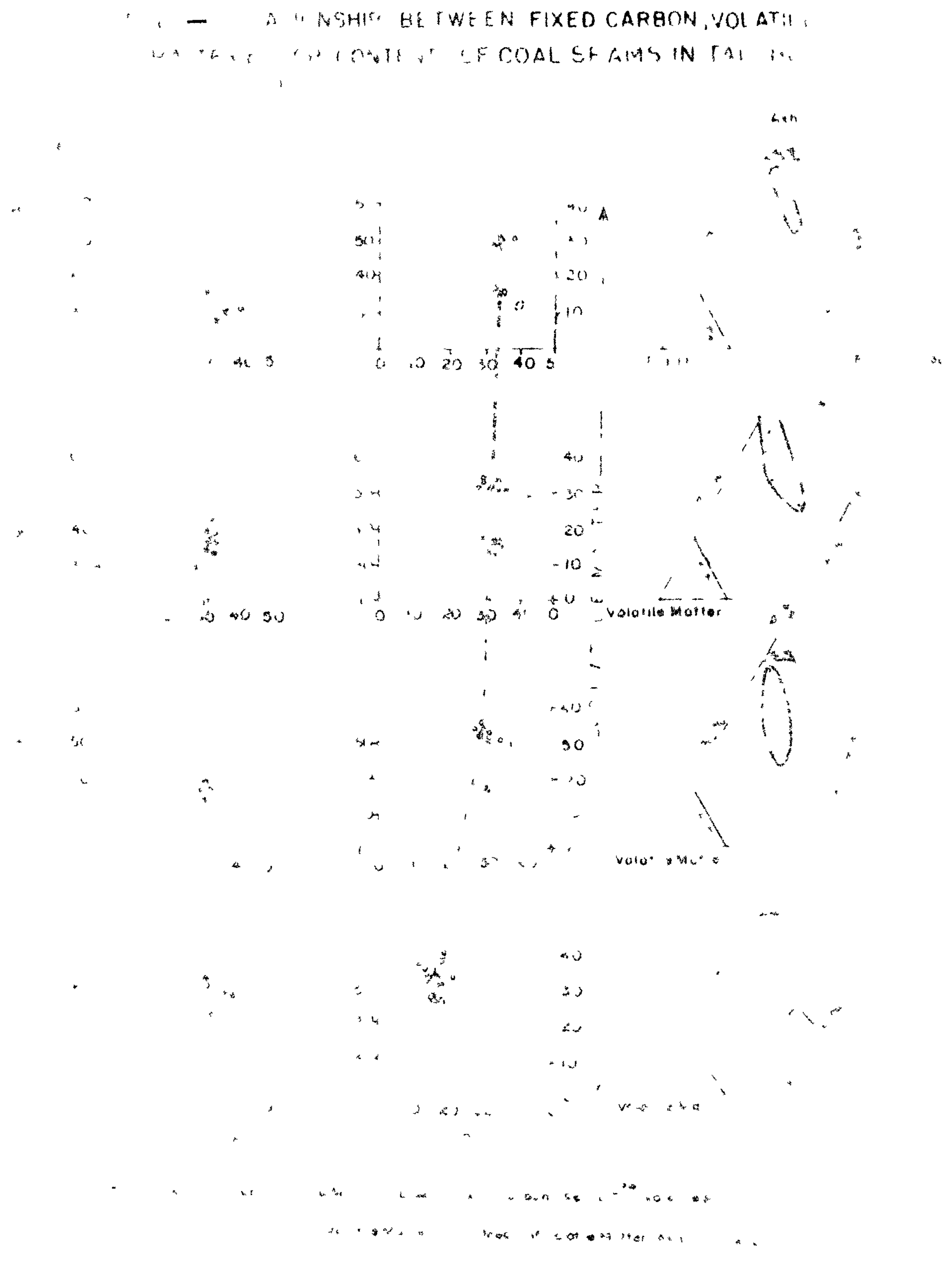

BETWEEN FIXED CARBON ,VOLATI
COAL SEAMS IN
Ash
A
50
40
20
10
0
10
20
30
40
50
Volatile Matter

Fig. 8

A

B

content increases from 16.9% to 34.4%, progressively from bottom seam I to top seam IV. The volatile matter also decreases from bottom seam (34.2%) to top seam (20.1%), contrary to a general notion that volatile matter tends to increase and fixed carbon decreases in successively younger seams. This unusual behaviour of volatile matter may be result of differ nce in petrographic composition, and calls for a suitable explanation.

The systematic variation in per cent values of the proximate constituents from bottom to top seam in the coalfield is also evident from Table 3, below.

TABLE 3: Average per cent of proximate constituents for coal seams of Talcher coalfield.

No. of Seam	Average Per Cent		
	Fixed Carbon	Volatile Matter	Ash
IV	35.5	30.1	34.4
III	36.4	31.4	32.2
II	36.9	32.3	30.7
I	48.9	34.2	16.9

Korba Coalfield

The basic data for six seams of the Korba coalfield are listed in Appendix 2 and graphically plotted on a triangular coordinate paper in Fig. 9. The variation lines (Fig. 10a) showing inter-relationship of the three components,

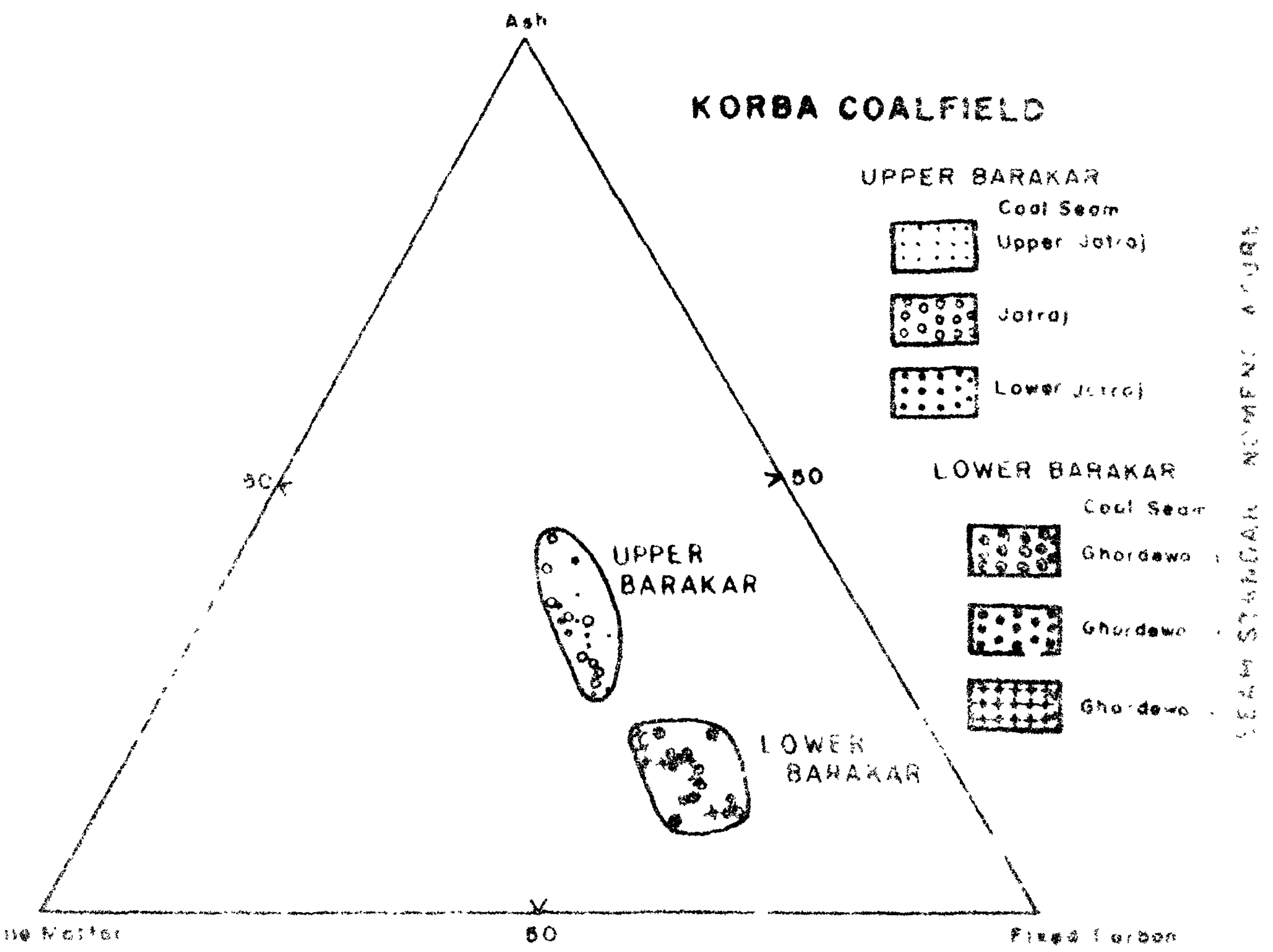


Fig. 9 : A triangular plot showing recalculated percent values of the three proximate constituents in six coal seams of Korba coalfield.

Fig. 10 : (A) Variation lines showing inter-relationship between the three proximate constituents of coal seams with depth in Korba coalfield.

(B) Triangular plots for each of the six coal seams of Korba coalfield showing temporal variation in proximate constituents from bottom to top seam.

INTER-RELATIONSHIP BETWEEN FIXED CARBON, VOLATILE MATTER AND ASH CONTENTS OF COAL SEAMS IN KORBA COALFIELD

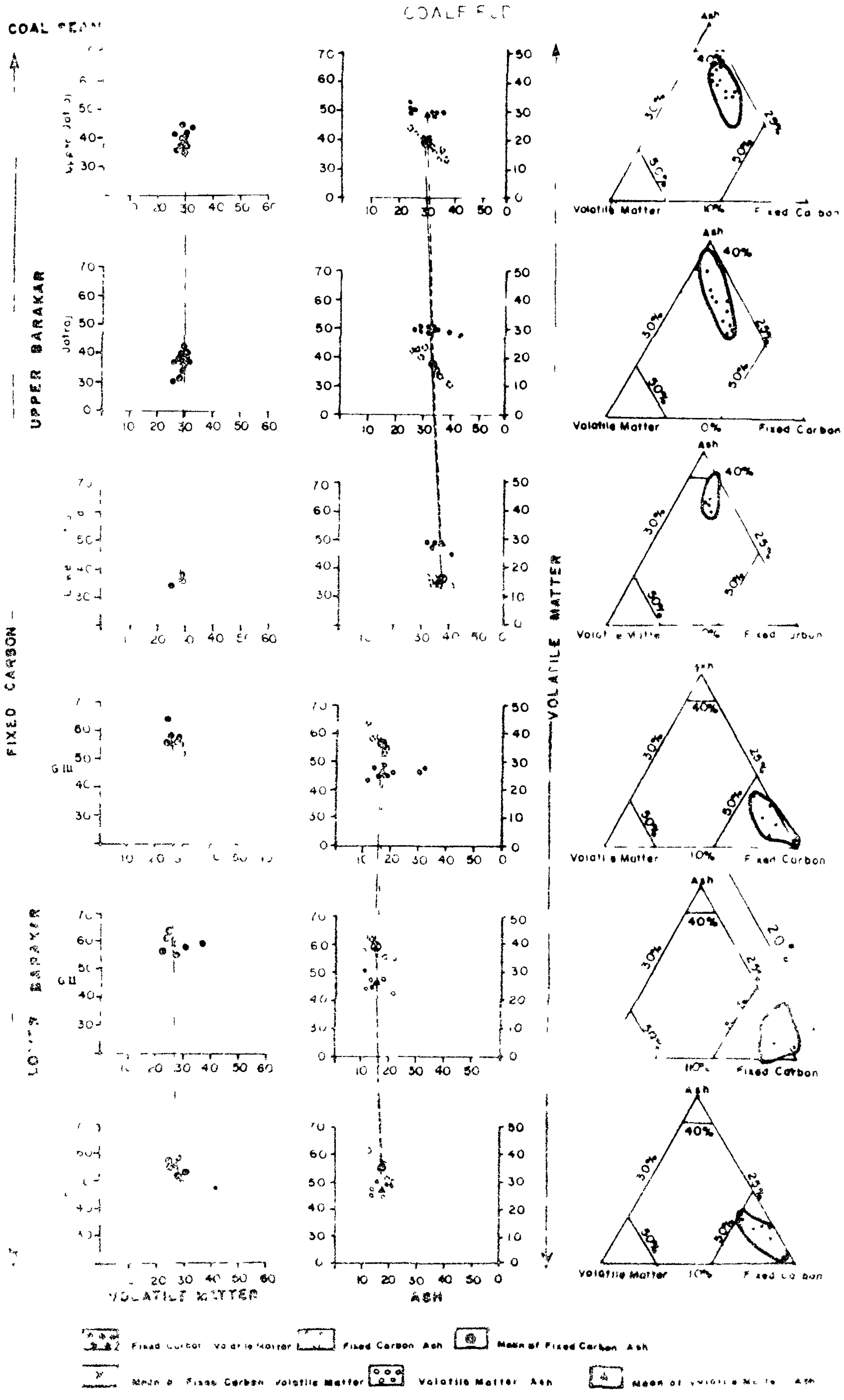


Fig. 10 A B

similar to that referred to earlier, exhibit the trend of variation in proximate constituents of coal from lower Barakar to upper Barakar. The plots reveal a gradual decrease in average percentage of fixed carbon (57.3 to 37.7%), but increase in volatile matter (26.9 to 28.1% and ash (15.7 to 33.3%) from lower to upper Barakar, in Korba coalfield.

The variation in proximate constituents of each coal seam from bottom to top may also be tabulated as follows:

TABLE 4: Average per cent of proximate constituents for coal seams of Korba coalfield.

No. of Seam		Average Per Cent		
		Fixed Carbon	Volatile Matter	Ash
Upper Barakar	Upper Kusmunda or Upper Jatraj	39.9	29.1	30.9
	Lower Kusmunda or Jatraj	37.1	29.1	33.7
	Lower Jatraj	36.1	28.5	35.3
Lower Barakar	G - III	56.9	26.8	16.3
	G - II	59.6	26.2	14.3
	G - I	55.5	27.7	16.8

The average fixed carbon content of the lower Barakar which has a thickness of about 250 m is 57.3%, volatile matter 26.9% and ash 15.7%, while in upper Barakar strata having thickness of about 350 m, the average fixed carbon is 37.7%, volatile matter 28.9% and ash 33.3%. A pronounced increase in ash and decrease in fixed carbon from Ghordewa-III to Lower Jatraj is too conspicuous to be readily explained. The sequence and the specific horizon listed and referred to above need to be verified from the colliery records before the implications are seriously thought over.

Chirimiri Coalfield

The results of proximate constituents of seven seams of the Chirimiri coalfield (Appendix 3) and their triangular plots (Fig. 11) and inter-relationships (Fig. 12a) indicate that Chirimiri coals are comparatively low in ash with a slight upward increase (14.8% to 18.0%). There is a well marked decrease in fixed carbon (56.0 to 48.5%) and increase in volatile matter (29.1 - 33.4%) from bottom to top seams. The intermittent increase in fixed carbon and volatile matter in the so called upper seams can be attributed to split bands (IIA and IIB) of an older seam(II), and, therefore, call for a review in respect of proper correlation and sequence. The above variation in proximate constituents is found within a thickness of about 275 - 335 m of strata and is shown in Table 5.

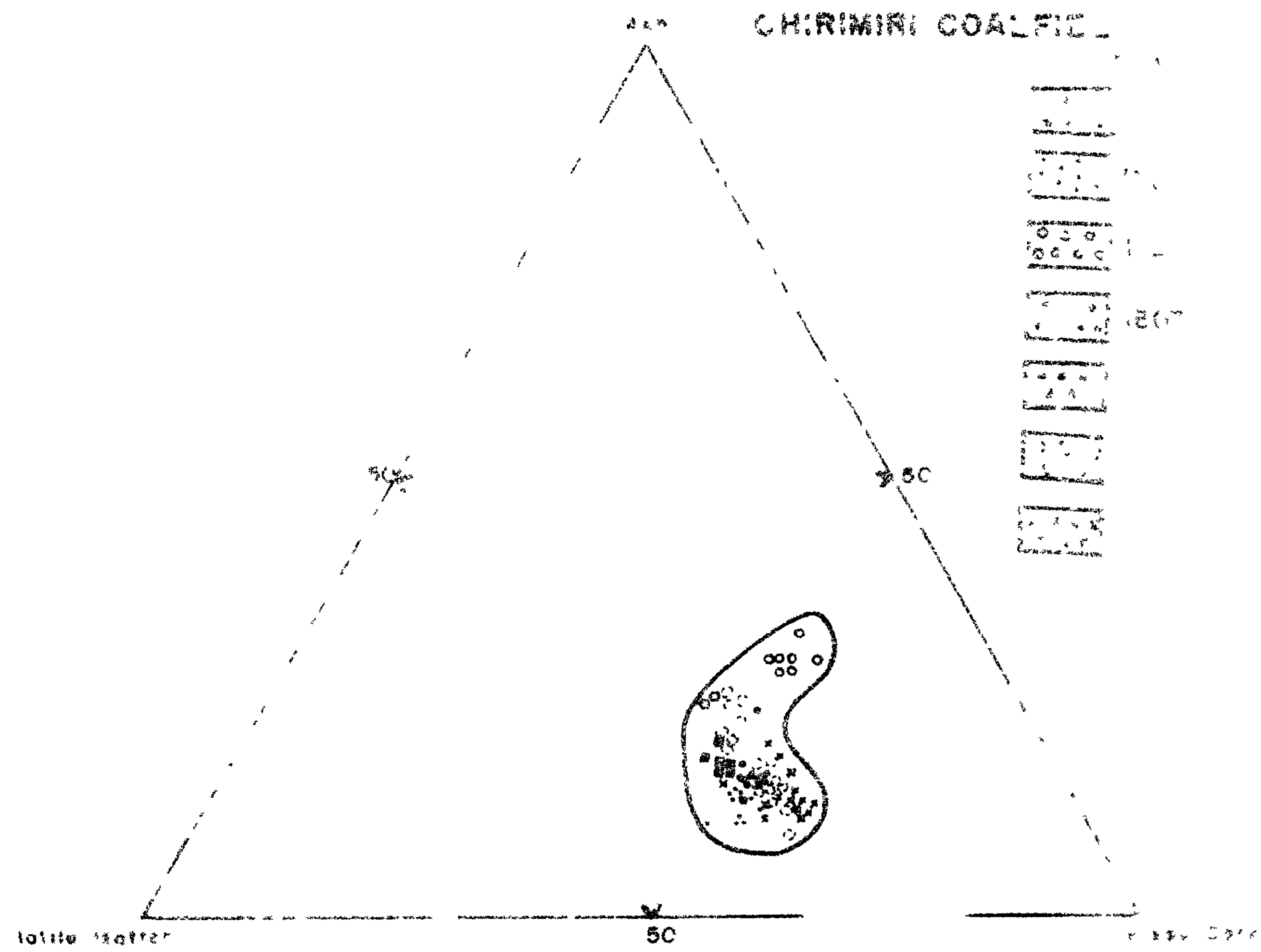


Fig.11 : A triangular plot showing recalculated percent values of the three proximate constituents of seven coal seams of Chirimiri coalfield.

Fig. 12: (A) Variation lines showing inter-relationship between the three proximate constituents of coal seams with depth in Chirimiri coalfield.

(B) Triangular plots for each of the seven coal seams of Chirimiri coalfield showing temporal variation in proximate constituents from bottom to top seam.

INTER-RELATIONSHIP BETWEEN FIXED CARBON, VALATILE MATTER & ASH CONTENTS OF COAL SEAMS IN CHIRIMIRI COAL FIELD

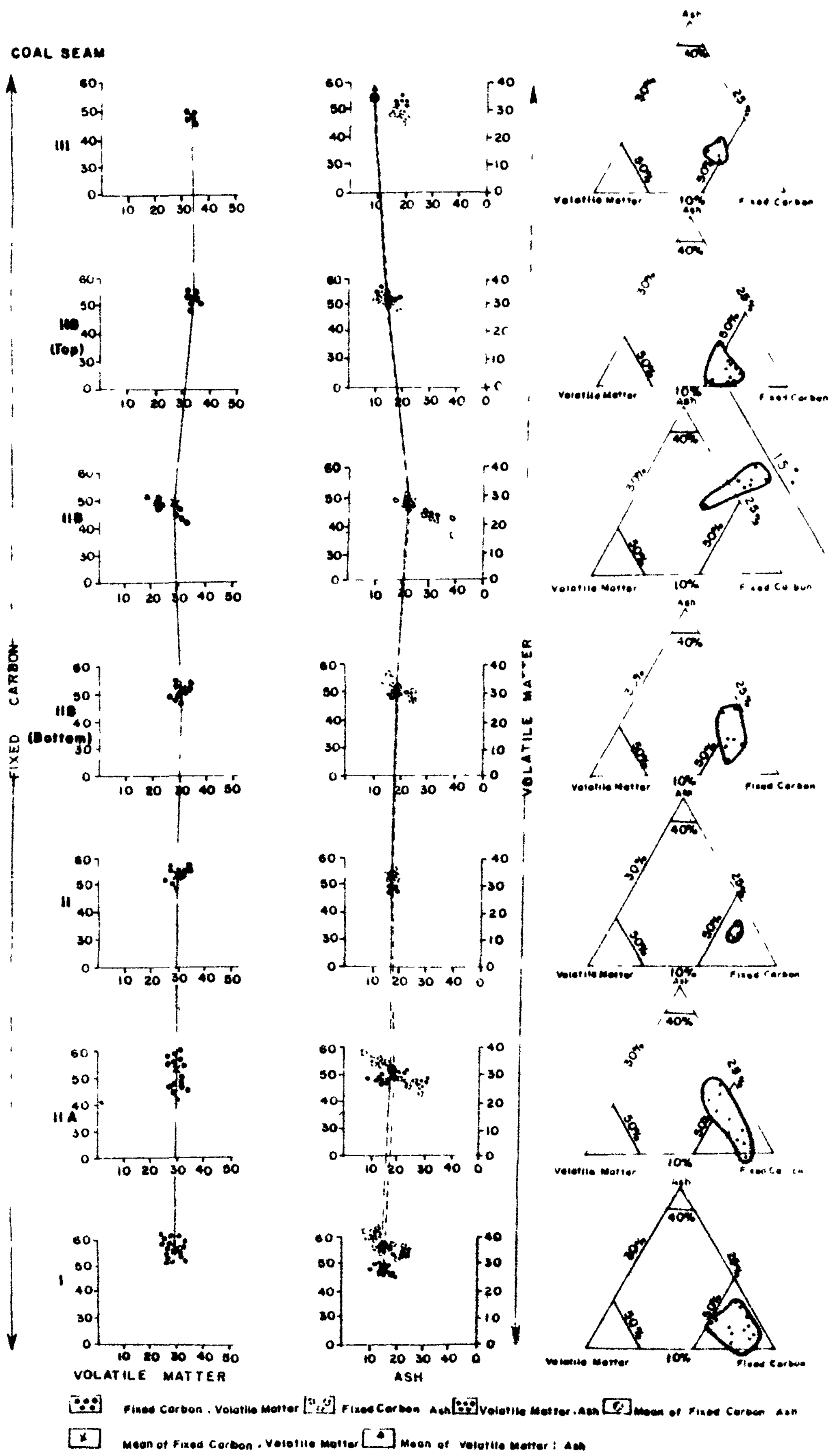


Fig. 12 A B

TABLE 5: Average per cent of proximate constituents for coal seams of Chirimiri coalfield.

No. of Seam	Average Per Cent		
	Fixed Carbon	Volatile Matter	Ash
III (Duman)	48.5	33.4	18.0
II B Top	52.5	34.2	12.9
II B	47.1	27.6	25.2
II B Bottom	52.0	31.0	17.0
II (Karakoh, Georghelia, Bijora and No. 3)	54.1	29.6	16.3
II A (No. 3A)	53.5	29.8	16.5
I (Kotma/Sonawani)	56.0	29.1	14.8

Sohagpur Coalfield

Two areas were considered for this study in the Sohagpur coalfield, namely Jhagrakhand-Bijuri area to the west and Kutkona-Bhaskarpara area lying to the east. Appendix 4 shows the recalculated proximate data for the four seams of Jhagrakhand-Bijuri area. Their graphic plots are shown as ternary diagram in Fig. 13 and variation lines in Fig. 14a. The variation lines illustrate a progressive decrease in fixed carbon content from bottom (55.2%) to top (48.7%) seams. Volatile matter also increases from bottom Seam-A to upper Seam-C (29.4 to 30.6%) but in the upper most Seam-D volatile matter registers a decrease to 28.2%. This

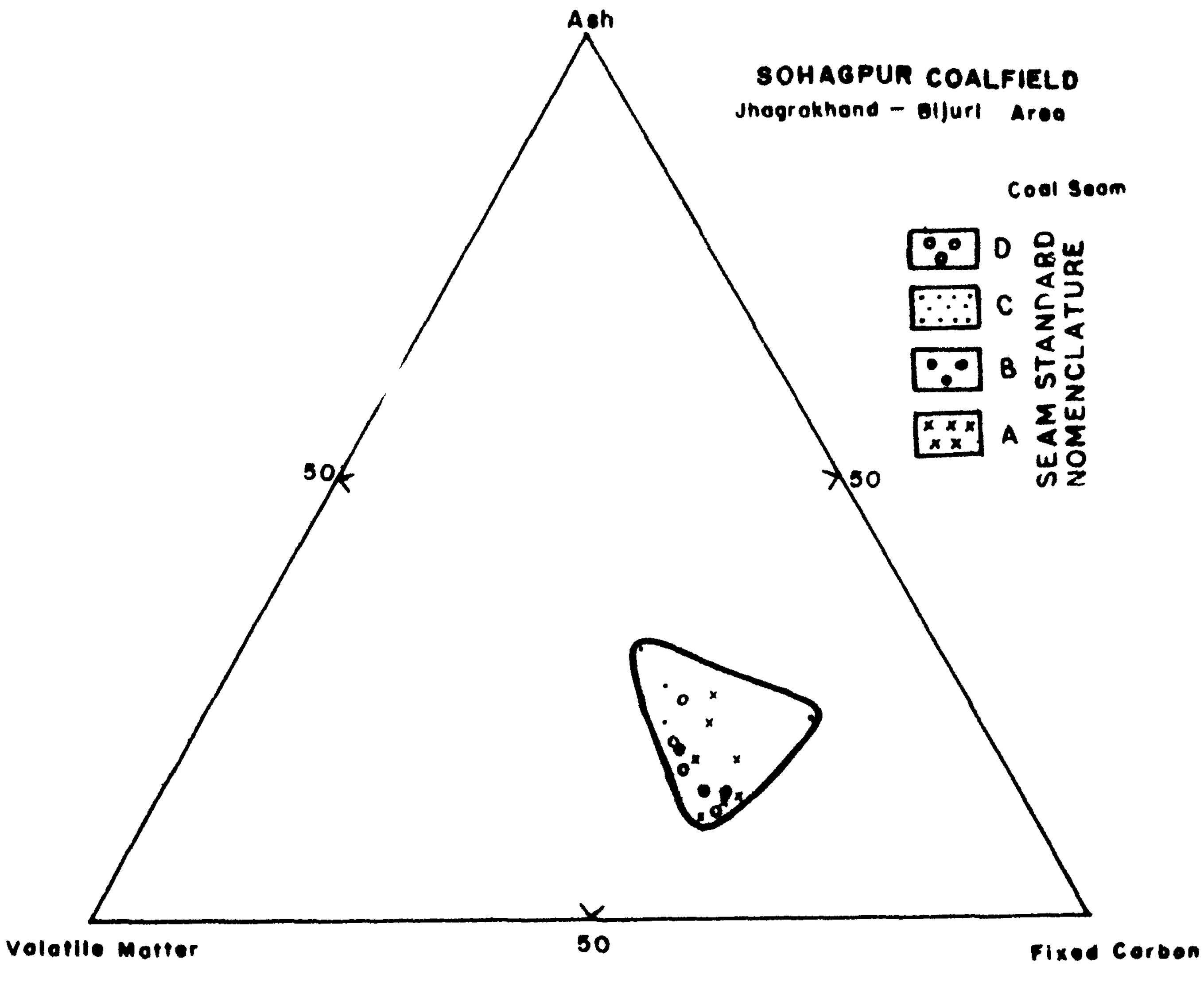


Fig. 13 : A triangular plot showing recalculated percent values of the three proximate constituents in four coal seams of Sohagpur coalfield (Jhagrakhand-Bijuri Area).

INTER—RELATIONSHIP BETWEEN FIXED CARBON, VOLATILE MATTER & ASH CONTENTS OF COAL SEAMS IN SOHAGPUR COALFIELD JHAGRAKHAND - BIJURI AREA.

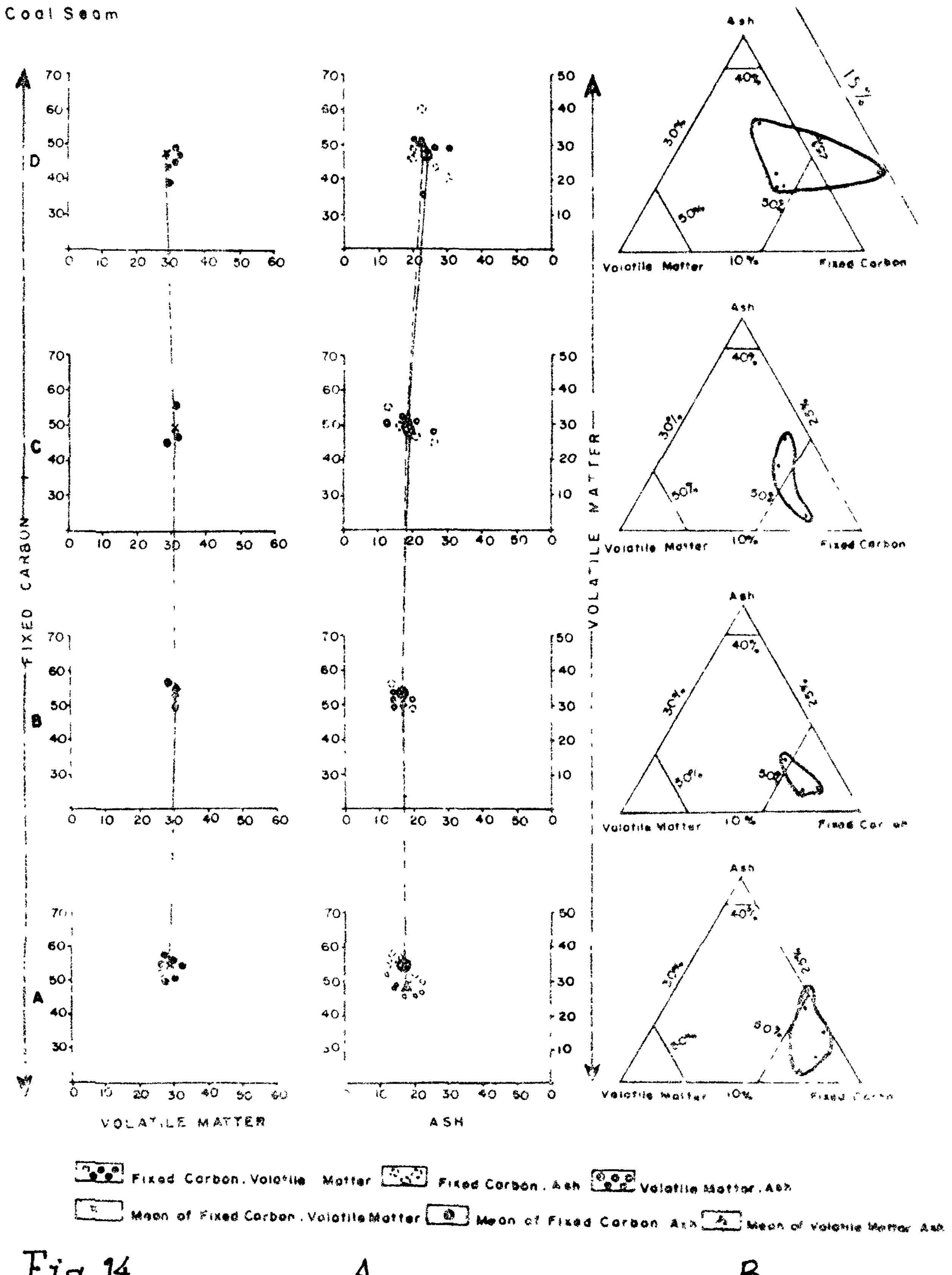


Fig. 14 A B

Fig. 14 : (A) Variation lines showing inter-relationship between the three proximate constituents of coal seams with depth in Sohagpur coalfield (Jhagrakhand-Bijuri Area).

(B) Triangular plots for each of the four coal seams of Sohagpur coalfield (Jhagrakhand-Bijuri Area) showing temporal variation in proximate constituents from bottom to top seam.

anomolous behaviour of volatile matter in the upper most seam is unaccountable from the given data but needs to be further verified and explained. Ash content is low(15.4 to 19.6%) in the lower seams from A to C but increases in the upper most seam appreciably to 23.1% . The coal seams of this area lie within the strata ranging in thickness from 9 0 to 1165 m and show the variation in proximate constituents as summarised seam-wise in Table 6, below.

TABLE 6: Average percent of proximate constituents for coal seams of Jhagrakhand-Bijuri area of Sohagpur coalfield.

No. of Seam	Average percent		
	Fixed Carbon	Volatile Matter	Ash
D	48.7	28.2	23.1
C	49.7	30.6	19.6
B	53.2	30.5	1[illegible].1
A	55.2	29.4	15.4

For Kutkona-Bhaskarpara area, the triangular plots and variation lines for the data(Appendix 4) are shown in Fig.15 and 16a, respectively. The variation lines demonstrate only a slight decrease in fixed carbon from bottom seam I (55.5%) to Seam III (52.5%), while a rapid decrease in the succeeding coal seams (49.7 % -41.3%). Similarly ash content shows a slight increase in lower seams from 16.5 to 17.2%, but a pronounced increase in upper seams from 21.0 to 32.3%.

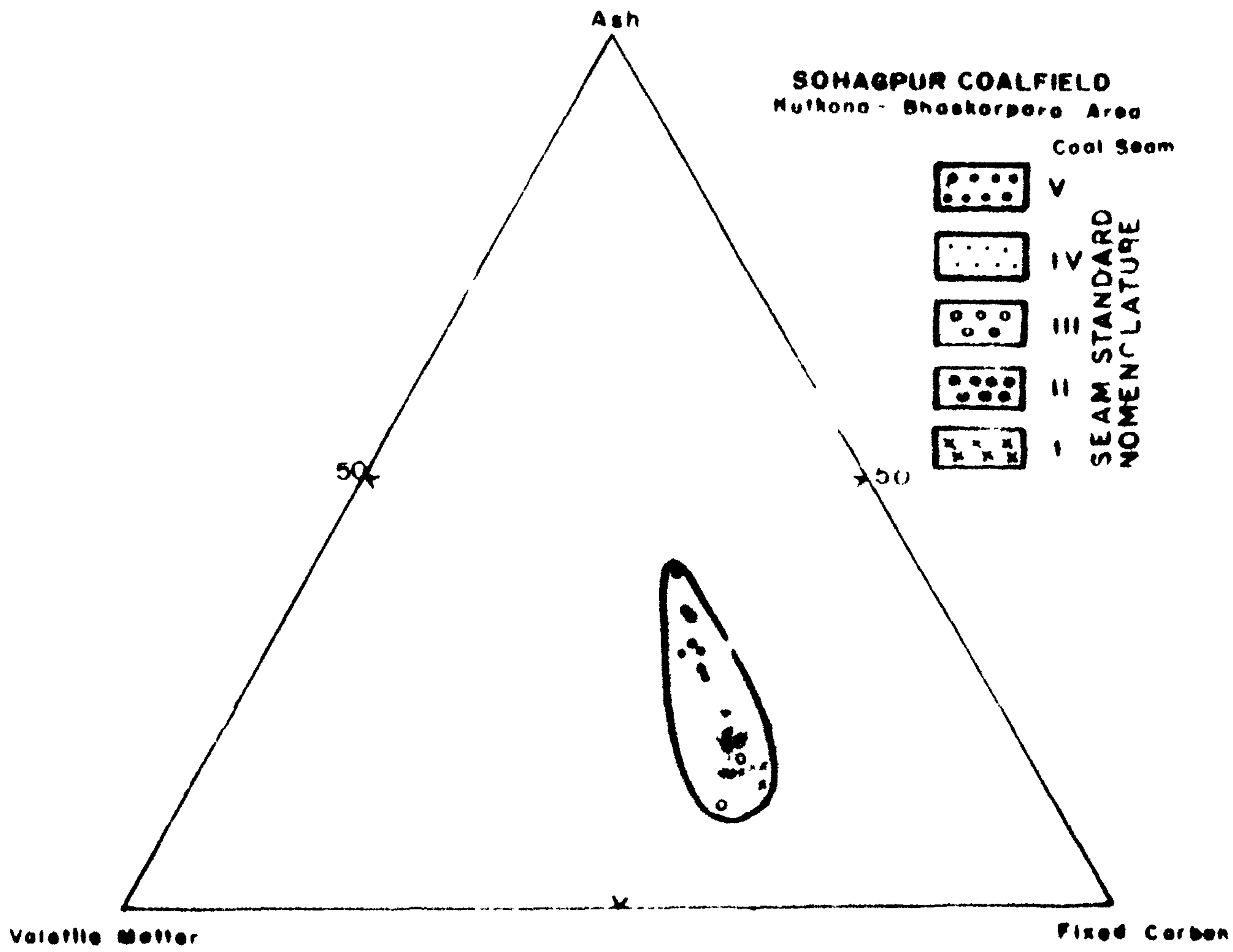


Fig. 15 : A triangular plot showing recalculated percent values of the three proximate constituents in five coal seams of Sohagpur coalfield (Kutkona-Bhaskarpara Area).

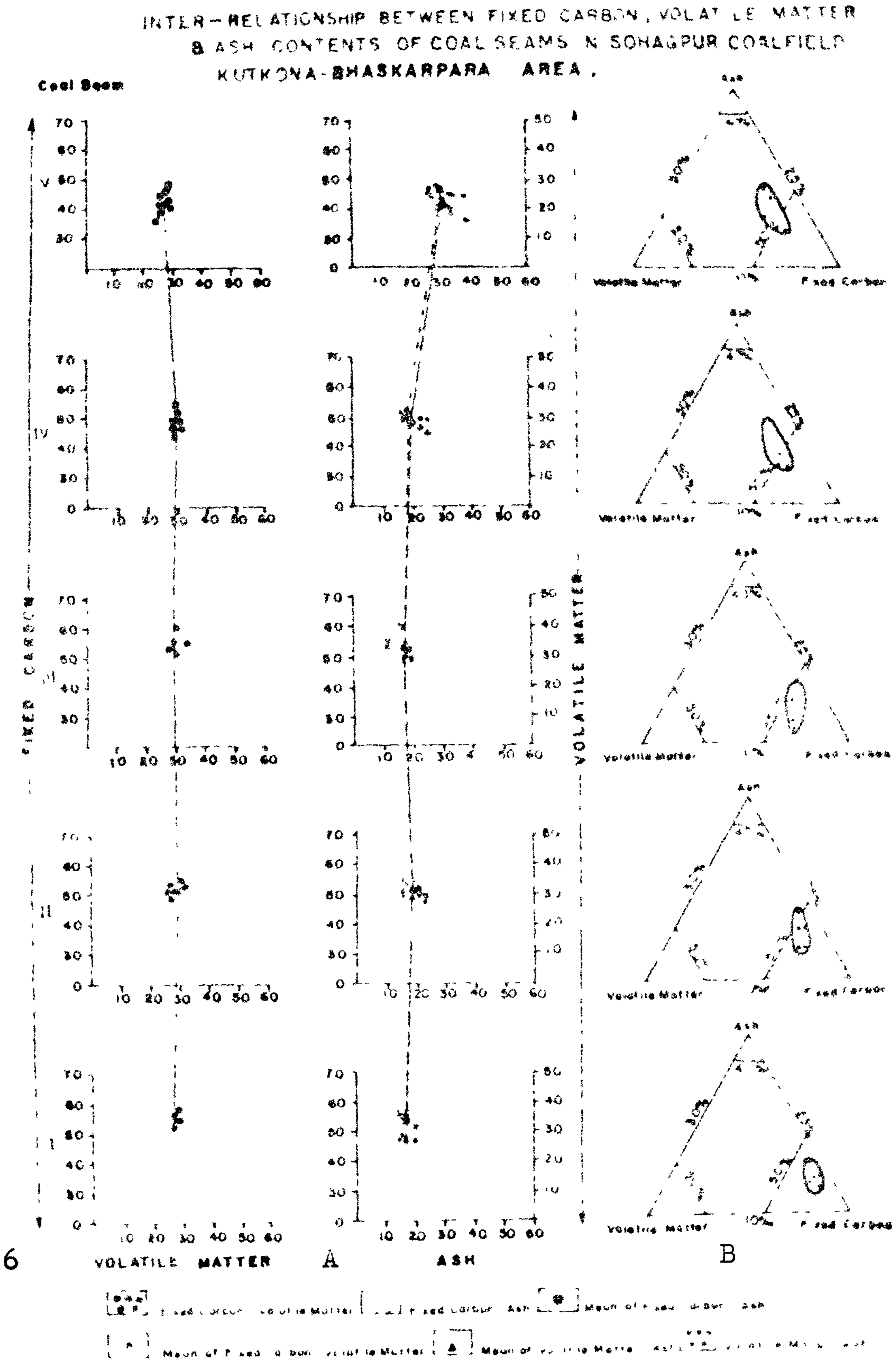


Fig. 16 A B

(A) Variation lines showing inter-relationship between the three proximate constituents of coal seams with depth in Sohagpur coalfield (Kutkona-Bhaskarpara area).

(B) Triangular plots for each of the five coal seams of Sohagpur coalfield (Kutkona-Bhaskarpara Area) showing temporal variation in proximate constituents from bottom to top seam.

The volatile matter,however,increases progressively from Seam I(28.2%) to Seam IV(30.9%) but decreases in uppermost seam V to 26.2%.The seam-wise variation of proximate constituents within the strata having thickness of about 5.5 m is summarized in table 7.

Table 7: Average percent of proximate constituents for coal seams of Kutkona-Bhaskarpara area of Sohagpur coalfield

No. of Seam	Average percent		
	Fixed Carbon	Volatile Matter	Ash
V	41.3	26.2	32.3
IV	49.7	30.9	21.0
III	52.5	30.1	17.2
II	51.8	29.5	18.7
I	55.5	28.2	16.3

Coalfield-wise Variation in Proximate Constituents

The chemical data of different seams in each coalfield were combined and frequency percent of the three proximate components calculated separately for each coalfield as listed in Appendix 5.

The results are used for evaluating: The average composition of the coal for each coalfield in terms of fixed carbon,volatile matter and ash ; spatial variation, if any, from Talcher coalfield in the southeast through Korba and

Chirimiri to Sohagpur coalfields in the northwestern part of the basin, and for evaluating the classification of Lower Gondwana coals in the Son-Mahanadi basin as a whole using volatile matter.

The percent frequency distributions of the three constituents is plotted as histograms separately for Talcher (Figs. 17A-C), Korba (Figs.18A-C), Chirimiri (Fig.19A-C) and Sohagpur (Figs. 20A-C to 21A-C) coalfields.

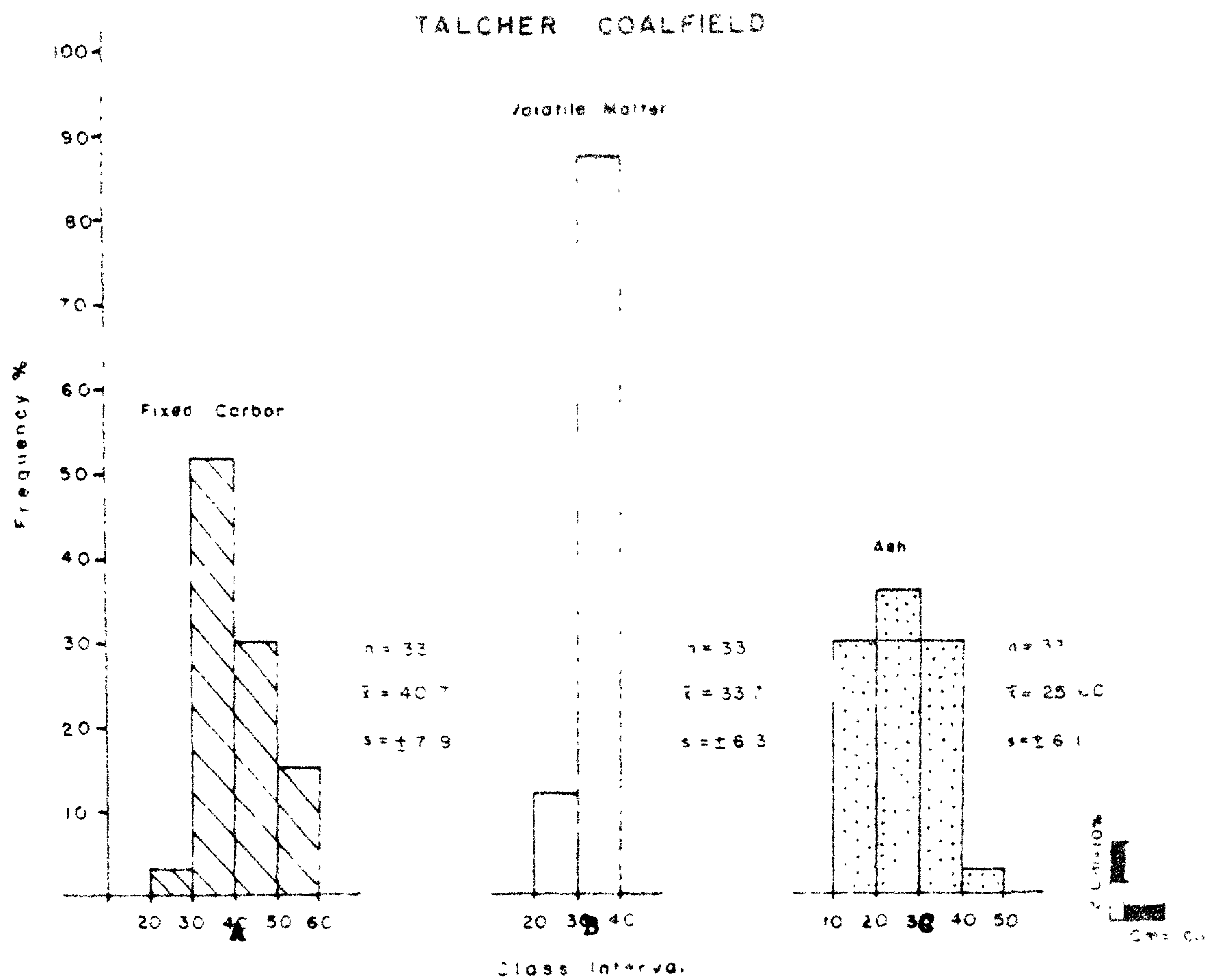
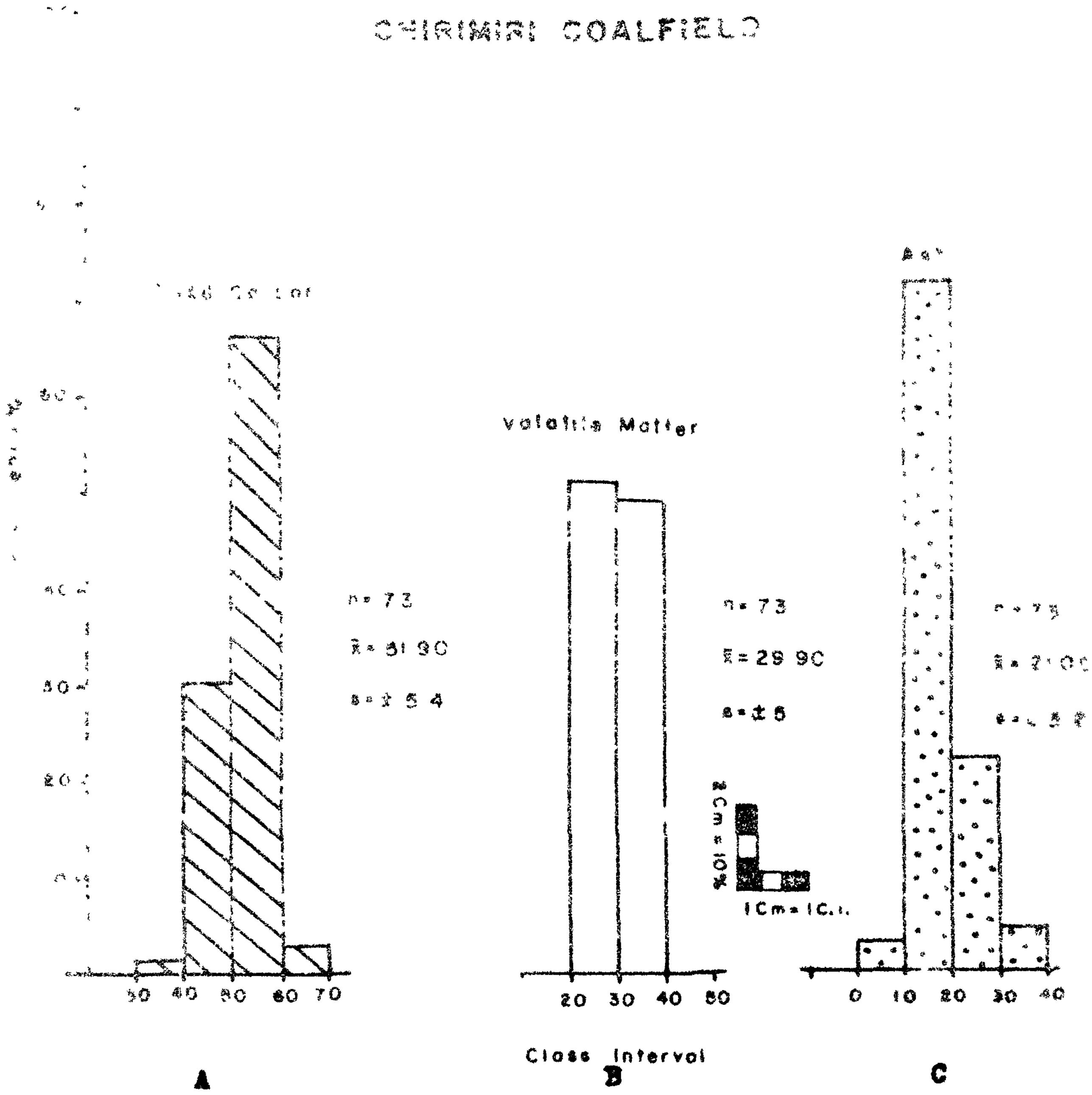


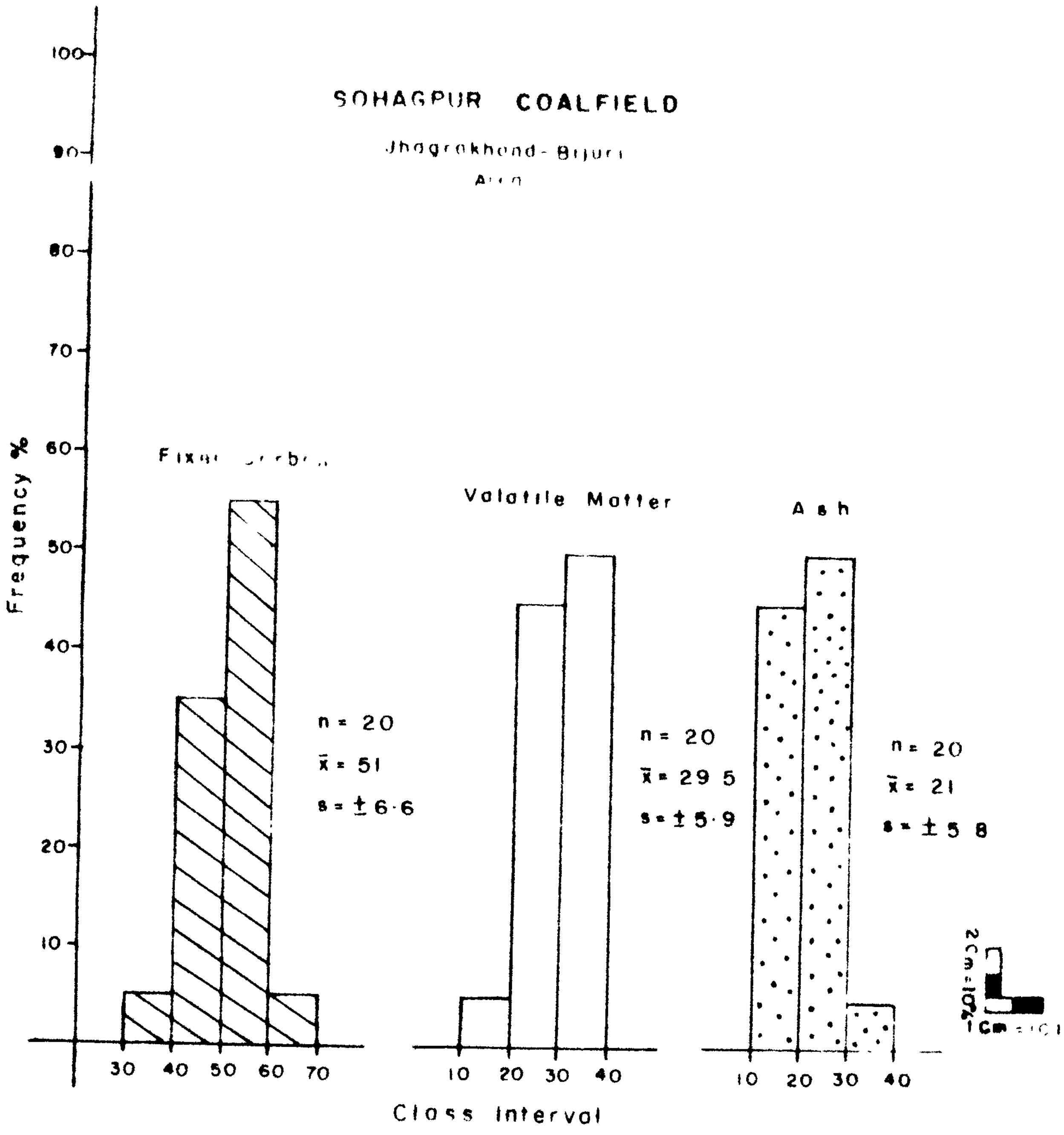
Fig.17 (A-C): Histograms showing percent frequency distribution of the three constituents(fixed carbo volatile matter and ash) in Talcher coalfield.

Fig. 18(A-C): Histograms showing percent frequency distribution of the three constituents (fixed carbon, volatile matter and ash), in Korba coalfield.



A B C

Fig.19 (A-C) : Histograms showing percent frequency distribution of the three constituents (fixed carbon, volatile matter and ash) in Chirimiri coalfield.



A B C

Fig.20 (A-C): Histograms showing percent frequency distribution of the three constituents (fixed carbon, volatile matter and ash) in Sohagpur coalfield (Jhagrakhand-Bijuri Area).

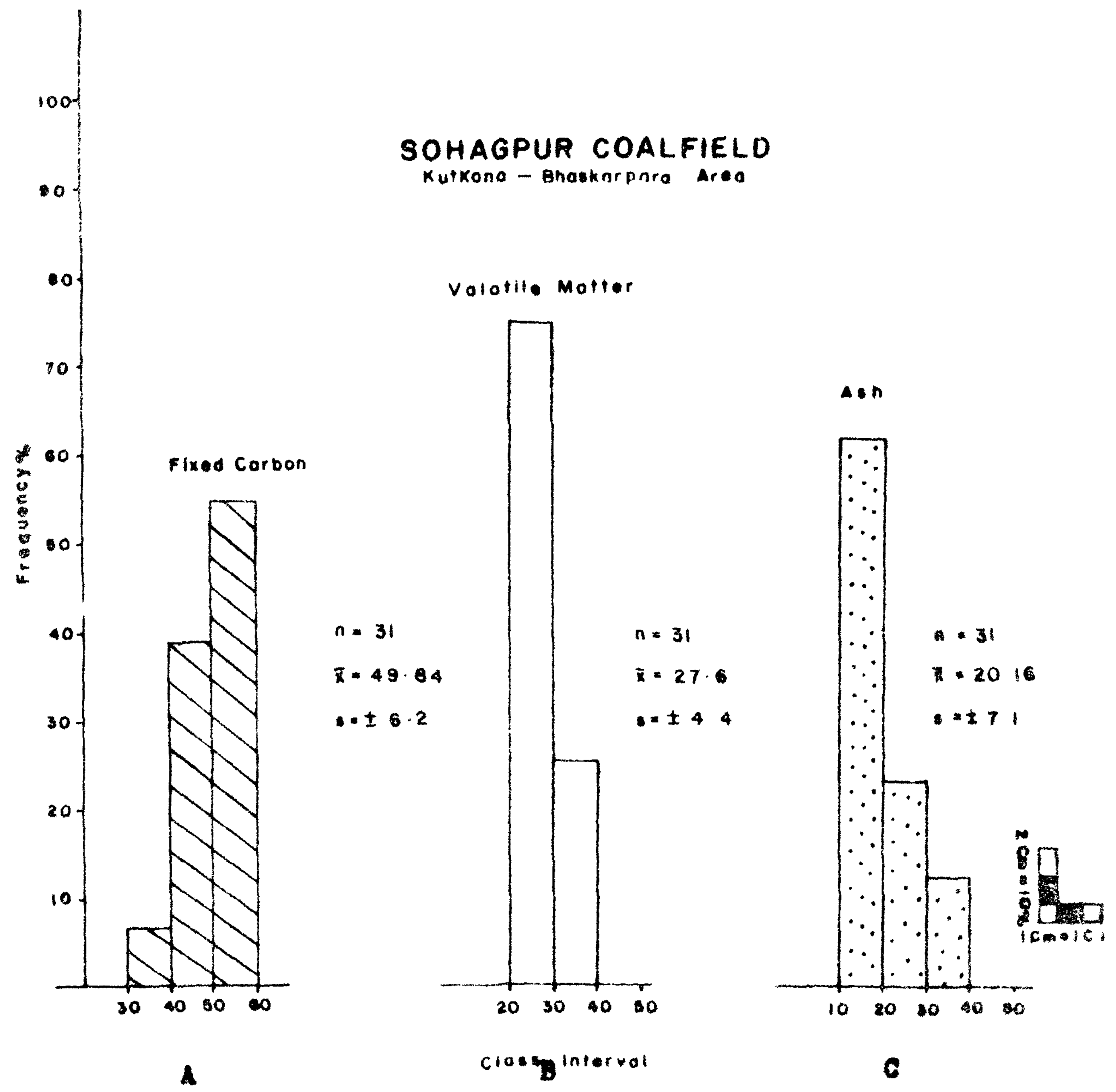


Fig. 21 (A-C) : Histograms showing percent frequency distribution of the three constituents (fixed carbon, volatile matter and ash) in Sohagpur coalfield (Kutkona-Bhaskarpara Area).

Chapter III

RESULTS AND INTERPRETATION

The results obtained from the synthesis of chemical data are discussed in terms of temporal and spatial variation within and between each coalfields.

Temporal Variation

The differences in chemical character of coal in the four seams of Talcher coalfield are well documented in respective set of triangular plots (Fig. 8b). A progressive increase in ash content and decrease in fixed carbon is well illustrated in these triangular plots from bottom to top seams implying temporal variation in the proximate constituents, and thereby in the quality of coal with depth. Thus, the lower seam of the (?) Karnarbari Formation of the Talcher coalfield is relatively low in ash (16.9%) and high in fixed carbon (48.9%), whereas top seams are higher in ash (34.4%) and lower in fixed carbon (35.5%). The temporal variation in volatile matter is, however, not so well marked as in the case of ash and fixed carbon.

The temporal variation in fixed carbon and ash, likewise, is well documented in six seams of the Korba coalfield (Fig. 10b). The lower Barakar coals are on an average low in ash (15.7%) and higher in fixed carbon (57.3%) as against the upper Barakar coals which are on an average higher in ash (33.3%) and lower in fixed carbon (37.7%). The volatile matter also increases from lower (26.9% to upper Barakar (28.9%) corroborating the temporal increase from the lower to the upper part.

In sevel coal seams of the Chirimiri coalfield, similar variation is evident (Fig. 12b) as a result of the progressive decrease in fixed carbon (56.0 to 46.5%) and a general increase in volatile matter (29.1 to 33.4%) from bottom seam I to top seam III. The Chirimiri coals are exceptionally low in ash with an average of 16.9% and a range from 14.8 to 18.0%.

The temporal variation in terms of fixed carbon, volatile matter and ash content is similarly found in coals of the Jhagrakhand-Bijuri area (Fig. 14b) and Kotkona-Bhaskarapara area (Fig. 16b) of Sohagpur coalfield as summarized in Tables 6 and 7.

Spatial Variation

The synthesis of the results and plots referred to above show that fixed carbon registers a systematic variation on an average from 40.7% in Talcher coalfield through 46.4% in Korba and 51.0% in Chrimiri to 50.4% in Sohagpur coalfields in a distance of about 275 Km from southeast to northwest (Appendix 6). The volatile matter follows more or less a reverse trend in that it decreases from 33.8 to 28.5%, and so does ash from 25.6 to 20.6% over the area. Hence, a general increase in the fixed carbon and decrease in volatile matter and ash is apparent in the chain of coalfields from southeastern part (Talcher) through Kobra and

Chiririri to northwestern part(ohagpur) of the basin implying the existence o spatial variation. The spati l variation in the chemical character of Karharbari/Barakar co ls is clearly demonstrated in Fig. 22 for the average value of ash, v lat le matter and fixed carbon from Talcher coalfiel through Korba and Chirimiri to ohagpur coalfields. It may be summarised that the coals in this basin show a defenite variation in the overall qual ty from southeast to northwest, in that they are rel tively higher in ash,higher in volatile mat r and lower in fixed carbon in southeastern Talcher coalfield and lower in ash, lower in volatile matter and higher in fixed carbon in the northwestern ohagpur coalfield.

Classification

The ? Karharbari/Barakar coals of different coalfields of the Son-Mah nadi basin is plotted appropri tely in Fi . 23 which shows different stages of rank of coal according to German (DIN) and North merican (ASTM) scheme of classification based on average percent ge of volatile matter. inasmuch as the average volatile m t er in the coal seams of Son-Mahanadi basin varies from 28.5% to 3 .8%, most of the coals may be assigned to 'High Volatile Bituminous( )' which contain volatile matter ranging from 29 to 39% to 'Medium Volatile Bituminous' coals(volatile matter 2 -29%) as per above scheme of classific tion.

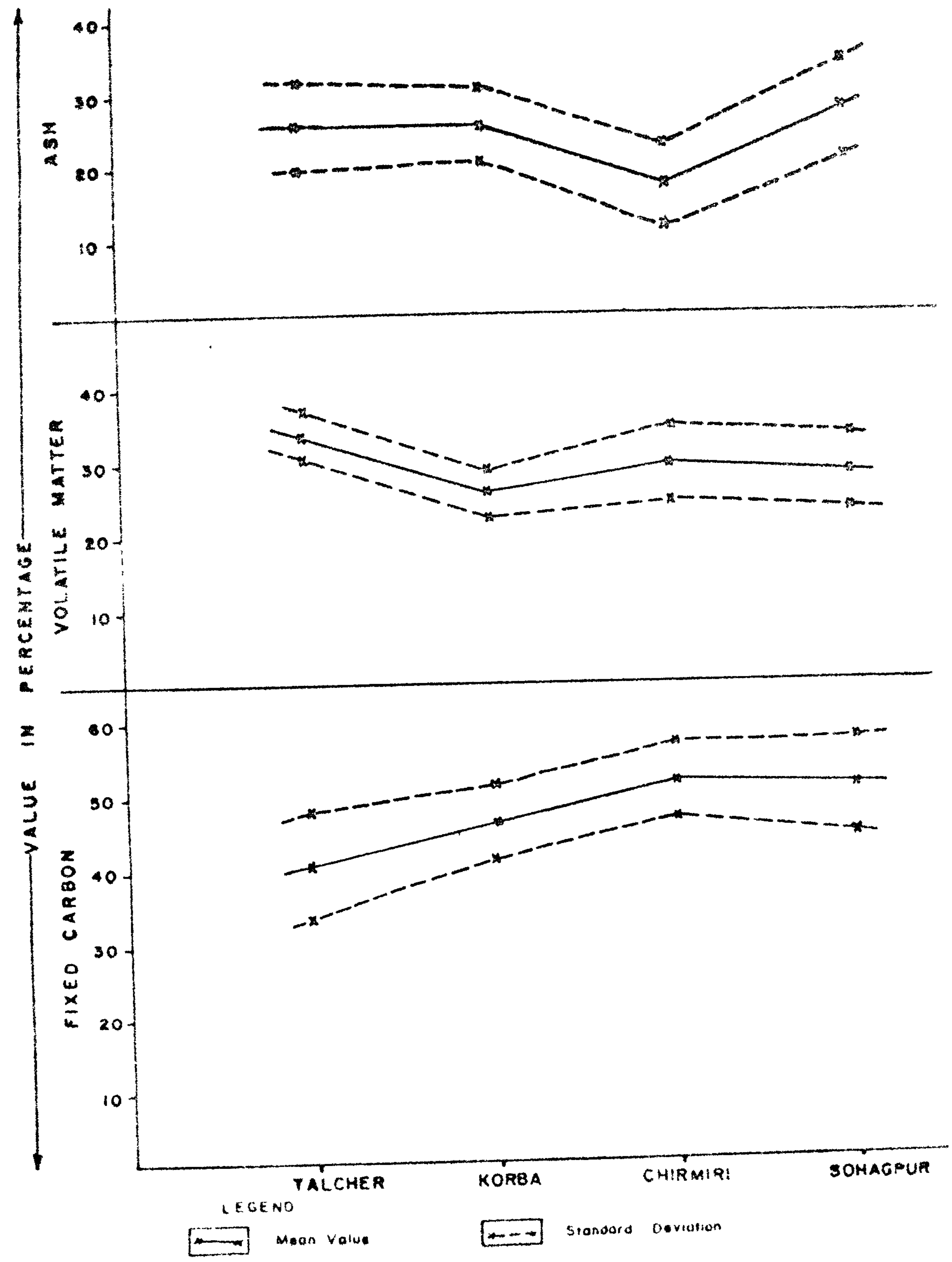


Fig. 22: Line diagram showing spatial variation of average fixed carbon, volatile matter and ash from Talcher coalfield through Korba and Chirimiri to Sohagpur coalfield.

The coals of Talcher coalfield which contain average volatile matter in order of 33.8 to 3.5% may be classified as 'High Volatile Bituminous(A)' coals(Fig.23). However, most of the Korba coals, especially those belonging to the lower coal seams, exhibit volatile matter 26.3 ± 3.4%, and these belong to 'Medium Volatile Bituminous' rank. By contrast, the coals of upper seams containing volatile matter (29.90± 5.0%) are 'High Volatile Bituminous(A)' in rank. The Chirimiri and Sohagpur coals, likewise, range from Medium Volatile to High Volatile Bituminous (A) rank.

INTERPRETATION

The ash in coal may be attributed to finely divided inorganic detritus which is disseminated in durain, fusain and clarain in variable proportion or to 'dirt' bands which from separate laminae in coal seams. Its ultimate source is the abundance of silt and clay which flush into coal forming swamps during the process of sedimentation. The progressive increase in ash content from the lower to upper coal seams in each coalfield as revealed from this study can evidently be attributed to greater influx of fine clastics into successively younger coal forming swamps, as they developed through time in the given alluvial plain, associated with channel and overbank facies. The increase in fine clastics in successively younger coal swamps may well be explained sedimentologically.

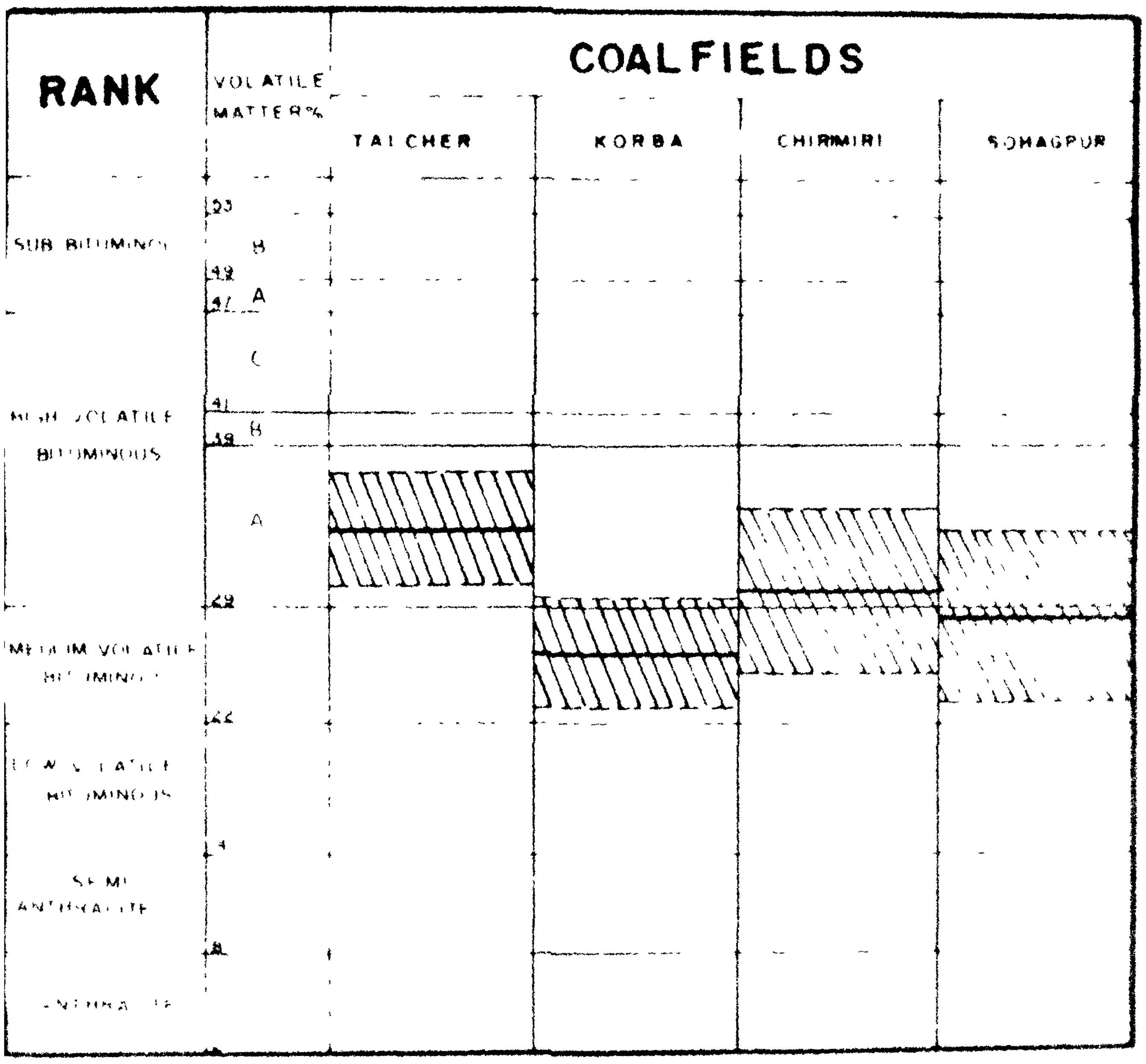


Fig. 23 : Diagram showing different stages of rank of coal according to German (DIN) and North American (ASTM) scheme of classification, based on average percentage of volatile matter. The rank of coal of Talcher, Korba, Chirmiri and Sohagpur coalfields is shown with separate columns based on average volatile matter.

The Karharbari river system which marked the onset of fluvial sedimentation brought into basin the sediment which consisted largely of pebbles, very coarse to coarse sand and partly fine clastics. The Karharbari streams were moderately deep and wide and their sinuosity was low because of a steeper slope they followed(Casshyap and Khan,1982). As the sedimentation progressed through time from Karharbari to Barakar,the climate became warm and humid,topography more mature and slope of the basin gentle. The succeeding Barakar rivers gradually transported more and more fine clastics and attained greater channel sinuosity resulting in meandering character.

Thus, increase in the ash content in the successively younger coal forming peat swamps from Karharbari through lower to upper Barakar can well be attributed to increasing supply of fine clastics due to greater sinuosity of channel pattern as sedimentation progressed. Hence, a gradual change in the sedimentation model and associated environments was the dominating factor in determining the ash content of coal at any given time during the course of sedimentation in each basin through time.

Unlike ash, the fixed carbon shows a progressive decrease from bottom to top seam in most cases here examined. The temporal increase in ash and decrease in fixed carbon may imply that the supply of vegetal debris was curtailed as more and more fine clastics were flushed into the peat swamps as they developed successively with increasing channel sinuosity of depositing streams through time.

A temporal decrease in fixed carbon and an increase in ash content may, thus, be interpreted in the light of above mentioned sedimentation phenomena.

Chapter-IV

SUMMARY AND CONCLUSION

The study aims at determining the fuel properties and rank of coal in the Son-Mahanadi Gondwana basin belt from Talcher coalfield in the south-east through Korba and Chirimiri to Sohagpur coalfields in northwest, a distance of about 250 km. The area lies between N. latitudes 21°30' to 24°30' and E. longitudes 80°45' to 85°. A set of coal seams from bottom to top in each coalfield have been considered for determining temporal variation in rank and quality of coals.

1. The sedimentary characters of the associated sedimentary facies of Karharbari and Barakar formations were examined in Korba, Chirimiri and Sohagpur coalfields. The vertical relationship of coal seams with the underlying and overlying sedimentary facies was noted closely wherever possible.

2. A total number of 26 coal seams including 4 from Talcher, 6 from Korba, 7 from Chirimiri, 4 from Jhagrakhand-Bijuri area and 5 from Katukona-Bhaskarpara areas of Sohagpur coalfield, were considered for this study.

3. 218 analyses obtained from the publication of the CFRI, 1979, for the mentioned above seams were used for this study, with an average of 10 analyses from each coal seam and an average of 55 analyses from each coalfield.

4. The percent values of the three proximate constituents (fixed carbon, volatile matter and ash) were recalculated and plotted on a triangular coordinate paper using separate symbols for each coal seam in each coalfield.
5. The variation lines showing the inter-relationship between the three proximate constituents were drawn to demonstrate the temporal variation more clearly.
6. Temporal v ri tion is brought out in the individual triangular plots for each seam.
7. Histograms based on percent fmequency data of the proximate constituents were plotted for determining the overall variation inf fuel properties of coal separately for each coalfield.
8. Mean percent values and standard deviation were calculated for volatile matter and other two components of proximate analyses for each coalfield to suggest possible classification of on-Mahanadi Gondwana basin. It is inferred that the Lower Gondwana coals are on an average High Volatile Bituminous (A) for Talcher, Medium Volatile Bituminous for Korba, High Volatile Bituminous (A) for Chirimiri and Medium Volatile Bituminous for Joh gpur coalfields.
9. The variation in the fueld properties of coal has been explained by the progressive supply of the fine clastics in t e successive peart swamps through time, during the course of uninterrupted and continuous

sedimentation. Systematic increases in ash at the expense of fixed carbon from the lower to upper seams is an evidence of progressively greater influx of fine clastics in the peat swamps developed successively through time in different coal. This also suggests that depositing streams became more sinuous with decline in gradiment through time from Karharbari to Barakar as suggested by early workers.

REFERENCES

Ahmad, F.,1960, The Gondwana basins of sedimentation in India: Rec. Geol.Surv.India, 86,pp.523-536.

Basu, T.N., 1981, Correlation and classification of the basal and lower permian coal measures of India: In M.M.Creswell and P.Vella(Eds.)'Gondwana Five, V Int. Gond.Sump., Willington,p.87.

Basu, T.N. and Shrivastava, B.B.P., 1981, Structure and tectonics of Gondwana basins of peninsular India: In M.M.Creswell and P.Vella(Eds.) 'Gondwana Five' V Int. Gond.Symp. Wellington, pp. 125-132.

Bose, S.K., 1979, Sedimentological characters in Eastern Margin of Tataponi Basin, M.P., India with a note on its coal occurrences: IV Int. Gond.Symp., Calcutta, v-II,pp. 671-682.

Casshyap,S.M.,1963, Sclerotoides in Kargali coals of East Bokaro: Curr. Sci., 32, pp. 263-264.

--------------, 1967, Microstructure of vitrinite of the Bokaro coals, Bull. Dept. Geo.Deptt.,A.M.U., Aligarh, v.3, pp. 1-13.

--------------, 1973, Paleocurrents and paleogeographic reconstruction in the Barakar (Lower Gondwana) sandstones of peninsular India: Sed.Geol.,v.9, pp. 283-303.

Casshyap, S.M., 1977, Patterns of sedimentation in Gondwana basins: IV Int.Gond.Symp.,1977,Calcutta,V-II, pp. 1-34.

————, 1981d, Lithofacies analyses of the late permian Raniganj coal measurers(Damuda basin) and their paleogeographic implic ti ns: In M.M. Creswell and P.Vella (eds.)'Gondwana Fi e'; V Int. Gond.Symp.,1980,Wellington, pp. 125-132.

————,1981b, Paleodrainage and paleogeography of Son Valley Gondwana basin, Mem: K.C.Mishra, commemm Kumaon University,Nainital,pp.132-142.

————,and Qidwai, 1974, Glacial sedimentation of late paleozoic Talcher diamictite,Pench Valley coalfield,central India : Bull Geol.Soc. America, v.85, pp. 749-760.

———— and Khan,Z.A.,1982, Paleohydrology of permian Gondwana streams in Bokaro basin, Bihar:Jour. Geo. Soc.India,v.23,pp. 419-430.

————and Tiwari,1983, Fluviatile Models of the lower permian coal measures of Son-Mahanadi and Koel Damodar valley basins, India, in press.

Chaudhary,A.,1979, Tectonic and paleogeomorphic evolution of Son-Mahanadi Gondwana basin-belt of Madhya Pradesh, India: IV Int.Gond.Symp.,1977, Calcutta, V.II,pp. 786-804.

Central Fuel Research Institute,Dhanbad, 'Indian coals',v.5&6, 1979.

De, A.K., 1979, Sedimentation in north Karanpura basin-modal in Damodar valley graben, peninsular India: IV Int. Gond. Symp., 1977, Calcutta, V.II, pp. 649-657.

Dutta, N.R., Dutta, A.B. and Majumdar, A..., 1979, Talchir Glaciation in the Son-Mahanadi and Koel valleys and adjoining areas, India: IV Int. Gond. Symp, 1977, v.I, pp. 354-359.

Frakes, L., Kemp, E. and Crowell, J.C., 1975, Late Paleozoic Glaciation: Part VI, pp. 454-465.

Ganju, P.N., 1955a, Petrology of Indian coals: Mem. Geol. Surv. India, 83, pp. 101.

----------, 1955b, The petrology of coals of the Daltonganj coalfield: Proc. Ind. Acad. Sci., v.42, pp. 14-26.

----------, 1960, The nature of microfragmental constituents of the Rampur coals: Proc. Ind. Acad. Sci., v.47, pp. 345-351.

---------- and Pant, I.L., 1963, the nature of resins in the Raniganj coals: Proc. Nat. Inst. Sc. India, v.29, No.2, pp. 192-212.

Ghosh, P.K. and Mitra, N.D., 1972, A review of recent progress in studies of the Gondwanas of India: II Int. Gond. Symps. Pretoria, S. Africa, pp. 29-47.

----------, 1975, History of Talchir sedimentation in Damodar valley basins: Mem. Geol. Surv. India, v.105, pp. 1-117.

Ghosh, P.K., Deekshitulu, M.N. and Murthy, D... , 1964, The Barharbari in the Gondwanas of peninsular India: Rep. XII Int. Geol. Cong. 9, pp. 169-180.

Indian Bureau of Mines, 1962, Handbook of Industrial minerals and mineral consumers in India.

Joshi, R.K., Krishnan, S., Saingte, S.R. and Pandey, R.K., 1978, Preliminary geological assessment of quarriable potentiality of Gevra block of Korba coalfield, Bilaspur district, Madhya Pradesh: Rept. CMPDI, Nagpur (unpublished).

Laskar, B., 1979, Evolution of Gondwana coal measures: IV Int. Gond. Symp., 1977, Calcutta, v. 1, pp. 223-237.

Marshall, C.E., 1954, Introduction to a study of the nature and origin of fusain (fusinite), Fuel, v. 33, pp. 134-144.

Mitra, N.D., Bose, V. and Dutta, A.K., 1979, The problems of classification of the Gondwana succession of peninsular India: IV Int. Gond. Symp., 1977, Calcutta, v. II, pp. 463-469.

Mukherjee, B.C. and Dutta, J., 1959, Study of the coals from Sachra area, Ranchi district, North Karanpura coalfield with special reference to their chemical and petrological characters and their correlation: Proc. 46th Ind. Sci. Cong., Abst., pt. 3, p. 234.

Navale, G.K.B., 1965, Petrographic analyses of some coals from Talchir coalfield: Birbal Sahani Inst. Paleobotany, Lucknow, India, pp. 5-12.

______, 1979, Depositional environment of lower Gondwana coals of India; IV Int. Gond. Symp., 1977, Calcutta, v. II, pp. 248-254.

Pascoe, E.H., 1959, Manual of Geology of India and Burma: Government of India Publication, Calcutta, pp. 1-1343.

Pant, I.J., 1965, Microstructures of some woody tissues and pith related to the form genus Amoxylon in the Permian coal, Raniganj Coalfield, India. Jour. Geol. Soc. India, v.6, pp. 53-61.

Pareek, H.S., 1963, Petrology of Talchir coals: Econ-Geol, v. 58, No. 7, pp. 1089-1109.

Raistrick, A. and Marshall, C. E., 1939, The nature and origin of coal and coal seams. English Univ. Press. Ltd., London, p. 218.

Rao, C.S.R., 1983, Coalfields of India: G.S.I. Bull, Ser. A, No. 45, v.III.

Robinson, P.L., 1969, The Indian Gondwana formations - review in Gondwana stratigraphy: (Ed. A.J. Amos) Paris, pp. 201-268.

Sastri, M.V.A., and Shah, S.C., 1964, Permian marine transgression in Peninsular India: Rep. XXII Int. Geol. Cong. pp. 139-150.

Stach, E., Mackowsky, M.T., Teichmuller, M., Taylor, G.H., Chandra, D. and Teichmuller, R., 1982, A text book of coal petrology: Berlin, Stuttgart 1982.

Tripathi, B., Kohli, M.L., Ghosh, A.K. and Chaudhary, R.K., 1977a: Geological Report on Deulbera Colliery, Talchir coalfield, CMPDI (unpublished).

RECALCULATED PERCENT VALUES OF FIXED CARBON, VOLATILE MATTER AND ASH FOR THE FOUR COAL SEAMS OF TALCHER COALFIELD, LOCALITY AND LOCAL NOMENCLATURE OF THE SEAM, WHEREVER POSSIBLE, AND THE SOURCE OF BASIC DATA.

APPENDIX-1

TALCHER COALFIELD

Area/ Block/ Sector	Seam Local Nomenclature	Seam Standard Nomenclature	Bore-hole No.	Depth from Surface (in meters)	Approximate Analysis % Fixed Carbon	Volatile Matter	Ash	Source
1.	2.	3.	4.	5.	6.	7.	8.	9.
Bharatpur	-	IV	NCTB - 162	16.5 Full Seam	36.19	30.90	32.91	Indian Coals Vol. 5, PP-303
-do-	-	"	NCTB - 174	19.8 " "	32.04	29.76	38.20	-do-
-do-	-	"	NCTB - 235	224.3 " "	40.54	31.15	28.31	-do-
North of Deulbera Colliery	-	"	TCh - 1	200.94 Bottom	33.37	28.69	37.94	-do-
Bharatpur Central Part	-	III	NCTB - 173	29.3 Full	33.96	32.20	33.84	-do- PP-304
-do-	-	"	TK - 16	244.81 Bottom	42.92	32.35	24.73	-do-
-do-	-	"	TK - 17	129.41 Full	36.80	33.37	29.83	-do-
Central Part	-	"	TK-HC- 1	13.6 Full	29.18	28.09	42.73	-do-
-do-	-	"	HC - 6	243.3 Full	34.27	30.59	35.14	-do-
-do-	-	"	HC - 1	55.40 Full	35.21	30.99	33.80	-do-, PP-305
Bharatpur	-	"	NCTB - 150	39.7 Sectional Seam	38.14	32.46	29.40	-do-, PP-306
-do-	-	"	NCTB - 161	16.6 Full Seam	37.10	31.03	31.87	-do-
-do-	-	"	NCTB - 240	29.13 Sectional Seam	39.70	31.56	28.74	-do-, PP-308
-do-	-	II	NCTB - 180	68.6 Full Section	40.18	35.54	24.28	-do-, PP-309
-do-	-	"	NCTB - 172	60.8 Full Section	35.85	34.70	29.45	-do-

contd. .... 2.

Page 2.

1.	2.	3.	4.		5.	6.	7.	8.	9.
Jagannath North India	-	II	TCh - 8	19.95	Full Seam	37.69	30.51	31.80	Indian Coals Vol. V, pp-310
Jagannath Colliery Area	-	"	TLR - 52	29.86	Full Seam	36.32	32.30	31.38	-do-
-do-	-	"	TLR - 84	9.00	Full Seam	39.53	33.33	27.14	-do-, pp-311
-do-	-	"	TLR - 87	7.60	Full Seam	38.74	32.44	28.82	-do-
Bharatpur	Jagannath	"	NCTB - 152	18.3	Top Part	34.89	30.54	34.57	-do-, pp-316
-do-	"	"	NCTB - 169	23.3	Full Seam	32.12	29.42	38.46	-do-, pp-317
West India	Bottom	I	TLR - 158	73.68	Bottom	48.39	38.62	12.99	-do-, pp-324
-do-	"	"	TCh - 11	86.10	Full Seam	53.09	32.83	14.08	-do-
Nandira Colliery Area	"	"	TLR - 104	71.51	Middle + Bottom Section	49.89	36.58	13.53	-do-
-do-	"	"	TLR - 105	33.38	Bottom	47.15	34.32	18.53	-do-, pp-325
-do-	"	"	TLR -112	57.30	Top	43.71	32.86	23.43	-do-
-do-	"	"	TLR - 124	76.15	Top	45.13	33.44	21.43	-do-, pp-327
-do-	"	"	TLR - 136	83.19	Top	50.65	31.74	17.61	-do-
-do-	"	"	TLR - 175	32.00	Top	44.58	36.44	18.98	-do-, pp-328
-do-	"	"	TCh - 9	124.12	Bottom	51.40	31.72	10.88	-do-, pp-329
-do-	"	"	TCh - 13	100.10	Bottom	46.68	35.01	18.31	-do-
West Talcher	Bottom or Main	"	NCTB - 247	151.43	Top	52.86	33.84	13.30	-do-, pp-334
-do-	"	"	NCTB - 252	123.40	Middle, Top Coal	53.06	32.33	14.61	-do-, pp-335

RECALCULATED PERCENT VALUES OF FIXED CARBON, VOLATILE MATTER AND ASH FOR THE SIX COAL SEAMS OF KORBA COALFIELD, LOCALITY AND LOCAL NOMENCLATURE OF THE SEAM, WHEREVER POSSIBLE, AND THE SOURCE OF BASIC DATA.

APPENDIX-2

KORBA COALFIELD

(UPPER BARAKAR)

Area/ Block/ Sector	Seam Local Nomenclature	Seam Standard Nomenclature	Bore-hole No.	Depth from Surface (in meters)	Approximate Analysis % Fixed Carbon	Volatile Matter	Ash	Source
1.	2.	3.	4.	5.	6.	7.	8.	9.
Jatraj	-	Upper Kusmunda (Upper Jatraj)	NCKK - 34	31.60 Full Seam	39.27	28.97	31.76	Indian Coals, Vol. 5, pp-212
Jatraj	-	-do-	NCKK - 1	45.41 Full Seam	40.10	29.41	30.49	-do-
-do-	-	-do-	NCKK - 4	95.91 Full Seam	43.57	31.14	25.29	-do-
-do-	-	-do-	NCKK - 34	49.85 Full Seam	41.38	26.92	31.70	-do-, pp-213
-do-	-	-do-	NCKK - 40	48.21 Full Seam	44.78	29.42	25.80	-do-
-do-	-	-do-	NCKK - 3	11.14 Full Seam	42.51	30.39	26.70	-do-, pp-214
-do-	-	-do-	NCKK - 7	53.37 Seam (including roof)	38.25	28.27	33.48	-do-
Manikpur-Lower Kachandi	-	-do-	D - 92	164.59 Full Seam	35.80	29.77	34.43	-do- pp-216
Dadar-Upper Kachandi	-	-do-	J - 9	50.05 Full Seam	37.25	29.27	33.48	-do-, pp-217
-do-	-	-do-	J - 43	115.47 Full Seam	36.04	27.29	36.67	-do-, pp-218
Jatraj	-	Lower Kusmunda (Jatraj)	NCKK - 20	10.45 Full Seam	39.96	28.89	31.15	-do-
-do-	-	-do-	NCKK - 28	95.25 Full Seam	40.19	30.01	29.80	-do-, pp-219
-do-	-	-do-	NCKK - 34	129.35 Full Seam	42.36	29.93	27.71	-do-,
-do-	-	-do-	NCKK - 35	74.97 Full Seam	38.37	27.70	33.93	-do-
-do-	-	-do-	NCKK - 41	30.70 Full Seam	41.67	29.70	28.63	-do-, pp-220
Pilot Quarry-Chitmali	-	Jatraj	D - 14	N.A. Full Seam	31.75	28.89	39.36	-do-, pp-221
-do-	-	-do-	K - 5	29.64 Full Seam	37.24	30.27	32.49	-do-
-do-	-	-do-	G - 4	27.74 Full Seam	35.64	29.86	34.50	-do-, pp-222
Manikpur - Lower Kachandi	-	-	D - 108	42.82 Full Seam	30.08	.18	49.74	-, pp-223

1.	2.	3.	4.	5.		6.	7.	8.	9.
Dadar-Upper Kachandi	-	Jatraj	J - 52	123.22	Full Seam	34.75	29.33	35.92	Indian Coals Vol. 5, pp-225
Pilot Quarry-Chitmali	-	Lower Jatraj-I	K - 6	63.17	" "	36.02	29.34	34.64	-do-,
Dadar Upper Kachandi	-	-do-	J - 8	154.96	" "	35.97	29.85	34.18	-do-, pp-226
Korba Colliery Area	-	-do-	NCKB - 19	109.19	" "	34.65	25.24	40.11	-do-,
Pilot Quarry-Chitmali	-	Lower Jatraj-II	K - 6	74.37	" "	37.70	29.67	32.63	-do-,
			(LOWER BARAKAR)						
Banki Surakachhar	-	G III (Ghordewa III)	-	N. A.	Bottom (working)	55.61	28.24	16.15	-do-, pp-230
-do-	-	-do-	-	N. A.	Full Seam	56.16	25.87	17.97	-do-, pp-231
Surakachhar	-	-do-	-	N. A.	Bottom(working)	58.68	28.16	13.16	-do-,
Banki-Surakachhar	-	-do-	-	N. A.	" "	59.01	25.46	15.53	-do-,
-do-	-	-do-	-	35.97	Full Seam	54.94	27.69	17.37	-do-, pp-228
Korba Colliery area	-	-do-	NCKB - 15 A	240.18	" "	64.08	23.96	11.97	-do-, pp-240
Banki-Surakachhar	-	G II (Ghordewa II)	G - 12	75.90	" "	63.48	24.96	11.57	-do-,
-do-	-	-do-	G - 28	225.93	" "	58.89	30.25	11.86	-do-,
-do-	-	-do-	G - 35	133.50	" "	59.55	27.64	12.81	-do-, pp-241
-do-	-	-do-	G - 41	75.67	" "	62.99	24.64	12.37	-do-,
-do-	-	G I (Ghordewa I)	G - 17	65.89	" "	54.89	28.65	16.46	-do-,
-do-	-	-do-	G - 36	188.65	" "	58.68	27.79	13.53	-do-, pp-243
-do-	-	-do-	G - 50	188.16	" "	62.36	25.13	12.51	-do-,
-do-	-	-do-	G - 71	189.20	" "	55.27	26.84	17.89	-do-, pp-244
-do-	-	-do-	G - 92	247.19	Top	57.68	25.06	17.32	-do-, pp-244
-do-	-	-do-	G - 198	72.26	Full Seam	53.89	30.02	16.09	-do-, pp-246
-do-	-	-	G - 210	132.88	Bottom	1.15	29.12	1 .78	-do-,

RECALCULATED PERCENT VALUES OF FIXED CARBON, VOLATILE MATTER AND ASH FOR THE SEVEN COAL SEAMS OF CHIRIMIRI COALFIELD, LOCALITY AND LOCAL NOMENCLATURE OF THE SEAM, WHEREVER POSSIBLE, AND THE SOURCE OF BASIC DATA.

CHIRIMIRI COALFIELD

APPENDIX-3

Area/ Block Sector	Seam Local Nomenclature	Seam Standard Nomenclature	Bore - hole No.	Depth from Surface (in meters)	Approximate Analysis %			Source
					Fixed Carbon	Volatile Matter	Ash	
1.	2.	3.	4.	5.	6.	7.	8.	9.
Chirimiri Colliery	No. I	III	Chrimiri	N.A. - Full Seam	50.75	32.83	16.42	Indian Coals, Vol. 6, pp-5
Duman Hill	Duman	"	CMR - 27	N.A. - "	46.56	35.27	18.17	-do-
-do-	"	"	CMR - 118	N.A. - "	47.84	32.07	20.09	-do-
-do-	"	"	CMR - 124	N.A. - "	48.97	33.55	17.48	-do-
Chirimiri Colliery	No. 2	II B Top	Chirimiri	N.A. - "	51.45	33.73	14.82	-do-
Kurasia	No. 1	"	Kurasia	N.A. - "	51.39	37.34	11.27	-do-
-do-	"	"	"	N.A. - "	53.89	35.13	10.98	-do-
-do-	"	"	"	N.A. - "	54.29	34.42	11.29	-do-
-do-	"	"	CMR - C2	28.78 - "	52.15	33.91	13.93	-do-
-do-	"	"	CMR - D2	11.05 - "	48.48	33.75	13.76	-do-
-do-	"	"	CMR - E2	20.19 - "	51.18	34.29	14.53	-do-
-do-	"	"	MCCK- 8	21.03 - "	53.46	32.58	13.96	-do-
-do-	"	"	MCCK- 11	24.38 - "	53.55	34.72	11.83	-do-
-do-	"	"	MCCK- 16	41.96 - "	55.29	32.18	12.53	-do-
Chirimiri Colliery	No. 3 Top	II B Bottom	Chirimiri	N.A. - "	53.34	33.11	13.55	-do-, pp-6
Kurasia	No. 2	"	Kurasia	N.A. - "	52.04	32.01	15.95	-do-
-do-	"	"	"	N.A. - "	48.21	28.90	22.89	-do-
-do-	"	"	"	N.A. - "	51.30	31.17	17.53	-do-
-do-	"	"	CMR - C1	31.06 - "	52.15	32.17	15.68	-do-
-do-	"	"	CMR - E1	22.12 - "	52.53	30.24	17.22	-do-
-do-	"	"	MCCK- 16	45.17 - "	54.61	29.29	16.09	-do-
-do-	No. 1 & 2	II B	CMR - 23	23.99 - "	47.75	29.39	22.86	-do-, pp-7
Duman Hill	Kaparti	"	-	N.A. - Bottom	49.35	28.45	22.20	-do-

-Page 2-

APPENDIX - 3 (contd).

1.	2.	3.	4.	5.	6.	7.	8.	9.
Duman Hill	Kaparti	II B	-	N.A. - Bottom	50.06	28.40	21.54	Indian Coals Vol. 6, pp-7
-do-	"	"	-	N.A. - Full Seam	48.76	29.45	21.79	-do-, pp-8
-do-	"	"	-	N.A. - "	37.75	23.50	38.71	-do-
-do-	"	"	CMR - 75	27.68 - "	51.03	27.81	21.16	-do-
-do-	"	"	CMR - 107	26.50 - Bottom	45.16	26.44	28.40	-do-, pp-9
Chirimiri Colliery	No. 3 Bottom	II	-	N.A. - Top	54.97	28.42	16.61	-do-, pp-10
-do-	"	"	-	N.A. - Bottom	50.64	28.97	20.39	-do-
Kurasia	"	"	-	N.A. - Full Seam	53.73	27.07	19.20	-do-
-do-	"	"	-	N.A. - "	53.13	27.20	19.66	-do-
-do-	"	"	-	N.A. - "	49.79	26.11	24.10	-do-
Kurasia (ex-Sonawani)	Karakoh (No.3)	"	-	N.A. - Top	51.03	28.24	20.72	-do-
-do- "	"	"	-	N.A. - Full Seam	54.19	28.73	17.08	-do-
-do- "	"	"	CMR - 41	23.24 - "	53.45	31.18	15.37	-do-, pp-12
-do-	"	"	CMR - 61	30.89 - "	54.42	29.92	15.66	-do-, pp-12
-do-	"	"	CMR - 78	33.53 - "	53.65	31.85	14.50	-do-
-do-	"	"	CMR - 128	24.38 - "	51.64	29.16	19.20	-do-
-do-	"	"	CMR - 47	18.47 - "	56.26	30.27	13.46	-do-
-do-	"	"	CMR - 112	21.51 - "	53.84	30.49	15.67	-do-
-do-	"	"	NOOK - 14	25.88 - "	55.67	27.15	17.18	-do-
-do-	No. 3	"	NOOK - 19	30.28 - "	58.16	27.85	13.98	-do-
Duman Hill	Gorghela	"	-	N.A. - Seam	56.17	31.26	12.57	-do-
-do-	"	"	CMR - 12	14.48 - Full Seam	53.77	27.76	18.47	-do-, pp-14
-do-	"	"	CMR - 36	52.38 - "	52.77	30.38	16.84	-do-
-do-	"	"	CMR - 52	45.75 - "	54.28	30.33	14.89	-do-
-do-	"	"	CMR - 65	29.65 - "	46.62	30.93	22.45	-do-

APPENDIX - 3 (contd)

1.	2.	3.	4.	5.	6.	7.	8.	9.
Duman Hill	Gorghela	II	CMR - 69	64.52 Full Seam	48.91	31.11	19.98	Indian Coals, Vol. 6, pp-15
-do-	"	II	CMR - 87	60.91 "	51.03	30.27	18.70	-do-, pp-15
-do-	"	"	CMR - 96	33.61 "	53.63	30.77	18.60	-do-
-do-	"	"	CMR - 105	47.87 "	54.27	32.49	12.94	-do-
-do-	"	"	CMR - 121	44.16 "	53.67	29.33	17.00	-do-, pp-16
-do-	"	"	CMR - 137	10.54 "	56.48	32.26	11.25	-do-
North Chirimiri	Bijora	No. II	-	N.A. Top	57.59	28.90	13.51	-do-
-do-	"	"	-	N.A. Full Seam	51.86	27.25	20.89	-do-, pp-17
Korea (Korea No.1)	"	"	-	N.A. "	54.10	29.82	16.08	-do-, pp-18
-do-	"	"	KR - 21	22.35 Top	49.63	31.97	18.40	-do-
-do-	"	"	KR - 72	34.70 "	55.01	34.85	10.14	-do-
-do-	"	"	KR - 92	15.25 "	49.54	32.24	18.12	-do-
-do-	"	"	NCCKR - 7	32.21 "	58.10	31.80	10.10	-do-
-do-	"	"	NCCKR - 13	41.78 "	54.30	33.20	12.50	-do-
-do-	"	"	KR - 24	30.12 Bottom	51.17	29.30	19.53	-do-, pp-20
-do-	"	"	KR - 74	24.39 "	53.33	30.48	16.19	-do-
-do-	"	"	KR - 92	18.19 "	54.87	31.25	13.58	-do-, pp-22
Korea	"	II	KR - 21	22.35 Full Seam	50.84	30.88	18.28	-do-, pp-23
-do-	"	"	KR - 32	13.87 "	54.83	29.97	15.20	-do-
-do-	"	"	KR - 45	13.41 "	52.83	30.31	16.86	-do-, pp-24
-do-	"	"	NCCKR - 10	38.40 "	57.06	27.88	15.06	-do-
West Chirimiri	Main	"	-	N.A. Top	60.86	24.69	14.45	-do-
-do-	"	"	-	N.A. Full Seam	59.60	27.38	13.02	-do-
New Chirimiri (Porni hill)	-	"	-	N.A. Top	47.94	29.99	22.07	-do-
-do-	Main	"	-	N.A. Bottom	55.96	27.98	16.98	-do-, pp-25
		"	-	N.A. "	60.74	27.68	11.58	-do-

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APPENDIX - 3 (contd)

1.	2.	3.	4.	5.	6.	7.	8.	9.
New Chirimiri (Porni hill)	Main	II	-	N.A. - Bottom	59.33	26.73	13.94	Indian Coals, Vol. 6, pp-25
Pure Chirimiri	"	"	-	N.A. - Top	52.73	28.67	18.60	-do-, pp-26
-do-	"	"	-	N.A. - Full Seam	52.83	29.60	17.57	-do-
Chirimiri Colliery	No. 4	II A	-	N.A. - Top	56.81	30.00	13.19	-do-
-do-	"	"	-	N.A. - -	55.63	29.47	14.89	-do-
Kurasia	No. 3 A	"	-	N.A. - Top	55.62	28.88	15.49	-do-
-do-	"	"	CMR - A1	29.34- "	54.75	31.08	14.16	-do-, pp-27
-do-	"	"	CMR - E1	59.05- Bottom	48.94	31.60	19.45	-do-
-do-	"	"	CMR - 1K	64.31- Top	52.72	29.80	17.47	-do-
-do-	"	"	CMR - 49	55.46- Middle	47.11	31.48	21.40	-do-, pp-28
-do-	"	"	NCCK - 2	69.24- "	46.72	28.46	24.81	-do-, pp-28
-do-	"	"	NCCK - 3	57.40- Top	60.04	30.34	9.61	-do-
-do-	"	"	NCCK - 15	23.50- "	57.23	28.08	14.68	-do-
-do-	Sonawani (No.4)	I	-	N.A. - Full Seam	58.63	28.41	12.95	-do-, pp-29
-do-	No. 4	"	CMR - A1	65.91- "	55.66	31.29	13.02	-do-
-do-	"	"	CMR - D1	83.84- "	55.70	29.08	15.21	-do-
-do-	"	"	CMR - 47	63.60- "	54.74	30.55	14.70	-do-
-do-	"	"	CMR - 115	63.48- "	59.20	28.38	12.41	-do-
-do-	"	"	NCCK - 1	83.79- "	53.82	27.50	18.65	-do-
-do-	"	"	NCCK - 7	45.72- Top	51.40	32.27	16.33	-do-
-do-	"	"	NCCK - 18	64.72 Full Seam	57.41	27.97	14.61	-do-, pp-30
Duman Hill	Kotmi	"	CMR - 63	45.72 "	56.15	32.06	11.79	-do-, pp-30
-do-	"	"	CMR - 31	47.80 "	59.75	30.63	09.63	-do-
-do-	"	"	CMR - 125	105.18 "	59.05	27.80	13.14	-do-, pp-31
Chirimiri (Pure)	5' Se	"	-	N.A. "	50.20	34.28	15.56	-do-

RECALCULATED PERCENT VALUES OF FIXED CARBON, VOLATILE MATTER AND ASH FOR THE FOUR COAL SEAMS OF JHAGRAKHAND-BIJURI AREA AND FIVE COAL SEAMS OF KUTKONA-BHASKARPARA AREA OF SOHAGPUR COALFIELD, LOCALITY AND LOCAL NOMENCLATURE OF THE SEAM, WHEREVER POSSIBLE, AND THE SOURCE OF BASIC DATA.

APPENDIX-4

SOHAGPUR COALFIELD

JHAGRAKHAND - BIJURI AREA

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Area/ Block Sector		Seam Local Nomenclature	Seam Standard Nomenclature	Bore-hole No.	Depth from Surface (in meters)		Approximate Analysis %			Source
							Fixed Carbon	Volatile Matter	Ash	
1.		2.	3.	4.	5.		6.	7.	8.	9.
Bijuri		A	D	BJR - 1	70,91	Sectional	46.17	31.66	22.17	Vol. 6, pp-122
-do-		"	"	BJR - 15	38.80	"	48.58	31.36	20.06	-do-
-do-		"	"	BJR - 44	66.73	"	47.98	32.02	20.00	-do-
-do-		"	"	BJR - 49	45.44	Full Seam	60.71	16.33	22.96	-do-, pp-123
-do-		"	"	BJR - 60	12.98	"	39.96	29.81	30.23	-do-
-do-		B	C	BJR - 8	123.29	Sectional	56.01	31.57	12.42	-do-, pp-124
-do-		"	"	BJR - 18	24.46	"	45.78	28.80	25.42	-do-
-do-		"	"	BJR - 39	75.31	Full Seam	47.47	31.58	20.95	-do-
-do-		C	B	BJR - 15	120.5	"	54.37	31.15	14.48	-do-, pp-125
-do-		"	"	BJR - 24	61.00	"	49.26	31.20	19.54	-do-
-do-		"	"	BJR - 42	115.38	"	56.13	29.56	14.31	-do-
-do-		Jhagrakhand	A	-	N.A.	Top	54.78	32.59	12.63	-do-
Rajnagar		"	"	-	N.A.	Bottom	55.83	26.80	17.37	-do-, pp-126
-do-		"	"	-	N.A.	Full Seam	57.47	28.21	14.32	-do-
-do-		West Jhagrakhand	"	-	N.A.	Top	51.43	30.33	18.24	-do-
Jhagrakhand		South Jhagrakhand	"	-	N.A.	Full Seam	56.60	29.04	14.36	-do-, pp-128

KUTKONA - BHASKARPARA AREA

Area/ Block Sector		Seam Local Nomenclature	Seam Standard Nomenclature	Bore-hole No.	Depth from Surface (in meters)		Fixed Carbon	Volatile Matter	Ash	Source
Kutkona	I	Khajara	V	MOKT- 22	55.76	Top	42.55	27.42	30.03	-do-, pp-172
-do-	II	"	"	MOKT- 68	33.88	Top	43.68	26.78	29.54	-do-, pp-174
-do-	"	"	"	MKBP- 41	24.85	"	40.35	25.94	33.81	-do-
-do-	"	"	"	MOKT-		Bottom	36	24.28	38.76	-do-

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APPENDIX-4 (contd)

1.		2.	3.	4.	5.		6.	7.	8.	9.
Kutkona	II	Khajara	V	NCKT - 43 A	88.09	Full Seam	44.86	27.25	27.89	Volume 6, pp-177
-do-	"	"	"	NCBP - 15	14.94	"	39.75	25.96	34.29	-do-, pp-179
-do-	I	Tengri	IV	NCKT - 7	78.49	"	48.53	31.97	19.50	-do-, pp-181
-do-	"	"	"	NCKT - 26	84.66	"	46.71	29.51	23.78	-do-, pp-181
-do-	II	"	"	NCKT - 43 A	118.19	"	44.76	29.45	25.79	-do-
-do-	"	"	"	NCKT - 56	110.95	"	49.94	31.13	18.93	-do-
-do-	"	"	"	NCBP - 41	49.07	"	47.70	32.41	19.89	-do-, pp-183
Bhaskarpara		"	"	NCBP - 52	12.22	"	50.64	31.06	18.30	-do-
Kutkona	I	Chamat	III	-	N.A.	"	51.82	29.28	18.90	-do-, pp-184
-do-	"	"	"	-	N.A.	"	50.62	29.69	19.69	-do-
-do-	"	"	"	NCKT - 12	349.15	"	52.82	28.04	19.14	-do-
-do-	"	"	"	NCKT - 35	290.14	"	53.60	28.64	17.76	-do-, pp-185
Bhaskarpara		"	"	NCBP - 1	135.38	"	54.62	33.82	11.56	-do-, pp-188
-do-		"	"	NCBP - 24	99.50	"	52.32	30.63	17.05	-do-
-do-		"	"	NCBP - 78	150.88	"	51.23	30.83	19.24	-do-, pp-189
-do-		Khond Top	II Top	NCBP - 2	56.51	"	53.01	31.12	15.87	-do-, pp-190
-do-		"	"	NCBP - 6	29.36	Seam + Roof	51.43	28.99	19.58	-do-
-do-		"	"	NCBP - 31	110.08	" + "	50.94	28.91	20.15	-do- pp-191
-do-		"	"	NCBP - 53	58.64	Full Seam	54.07	30.62	15.31	-do-
-do-		"	"	NCBP - 65	149.69	Seam + Roof	49.63	27.75	22.62	-do-, pp-192
Kutkona	I	Kutkona	I	-	N.A.	Working	54.75	29.51	15.74	-do-, pp-197
-do-	"	"	"	NCKT - 6	189.26	Top	57.66	28.16	14.18	-do-
-do-	"	"	"	NCKT - 18	104.39	Full Seam	55.41	28.32	16.27	-do-, pp-198
-do-	"	"	"	NCKT - 27	186.07	"	52.28	27.90	19.73	-do-, pp-199
-do-	"	"	"	NCKT - 39	40.67	"	57.23	27.17	15.60	-do-, pp-199

TABLE - 5

List of the three components (Fixed Carbon, Volatile Matter and Ash) of coal in each selected coalfield of Son-Mahanadi Gondwana basin belt showing frequency percentage.

FIXED CARBON			VOLATILE MATTER			ASH		
Class Interval	Frequency	Frequency %	Class Interval	Frequency	Frequency %	Class Interval	Frequency	Frequency %
1	2	3	4	5	6	7	8	9
			[illegible]					
20-30	1	3.03	20-30	4	12.12	10-20	10	30.30
30-40	17	51.51	30-40	19	57.57	20-30	12	36.36
40-50	10	30.30	40-50	-	-	30-40	10	30.30
50-60	5	15.15	50-60	-	-	40-50	1	3.03
			[illegible]					
20-30	-	-	20-30	45	86.53	10-20	20	38.46
30-40	18	34.62	30-40	7	13.46	20-30	11	21.15
40-50	11	21.15	40-50	-	-	30-40	19	36.54
50-60	19	36.53	50-60	-	-	40-50	2	3.85
60-70	04	7.69	60-70	-	-	50-60	-	-

1	2	3	4	5	6	7	8	9
			[illegible]					
20-30	-	-	20-30	37	50.68	0-10	2	2.73
30-40	1	1.37	30-40	36	49.32	10-20	52	71.23
40-50	22	30.14	40-50	-	-	20-30	16	21.91
50-60	48	65.75	50-60	-	-	30-40	3	4.10
60-70	2	2.74	-	-	-	40-50	-	-
			[illegible] ([illegible])					
10-20	-	-	10-20	1	5.0	10-20	9	45.0
20-30	-	-	20-30	9	45.0	20-30	10	50.0
30-40	1	5.0	30-40	10	50.0	30-40	1	5.0
40-50	7	35.0	-	-	-	-	-	-
50-60	11	55.0	-	-	-	-	-	-
60-70	1	5.0	-	-	-	-	-	-
			[illegible] ([illegible])					
20-30	-	-	10-20	-	-	10-20	19	61.29
30-40	2	6.45	20-30	23	74.19	20-30	8	25.8
40-50	12	38.70	30-40	8	25.8	30-40	4	12.9
50-60	17	54.83	40-50	-	-	40-50	-	-

APPENDIX - 6

Average per cent values of the three proximate constituents for each separate coalfield from Talcher through Korba and Chirimiri to Sohagpur coalfields.

Proximate Constituents	Talcher Coalfield (%)	Korba Coalfield (%)	Chirimiri Coalfield (%)	Sohagpur Coalfield (%)
Fixed Carbon	$n = 33$	$n = 26$	$n = 73$	$n = 25$
	$\bar{x} = 40.7$	$\bar{x} = 46.4$	$\bar{x} = 51.0$	$\bar{x} = 50.4$
	$\sigma = \pm 7.8$	$\sigma = \pm 5.5$	$\sigma = \pm 5.4$	$\sigma = \pm 6.4$
Volatile Matter	$n = 33$	$n = 26$	$n = 73$	$n = 25$
	$\bar{x} = 33.6$	$\bar{x} = 26.3$	$\bar{x} = 29.9$	$\bar{x} = 28.5$
	$\sigma = \pm 3.3$	$\sigma = \pm 3.4$	$\sigma = \pm 5.0$	$\sigma = \pm 5.1$
Ash	$n = 33$	$n = 26$	$n = 73$	$n = 25$
	$\bar{x} = 25.6$	$\bar{x} = 54.7$	$\bar{x} = 17.7$	$\bar{x} = 20.6$
	$\sigma = \pm 6.1$	$\sigma = \pm 4.9$	$\sigma = \pm 5.8$	$\sigma = \pm 6.4$